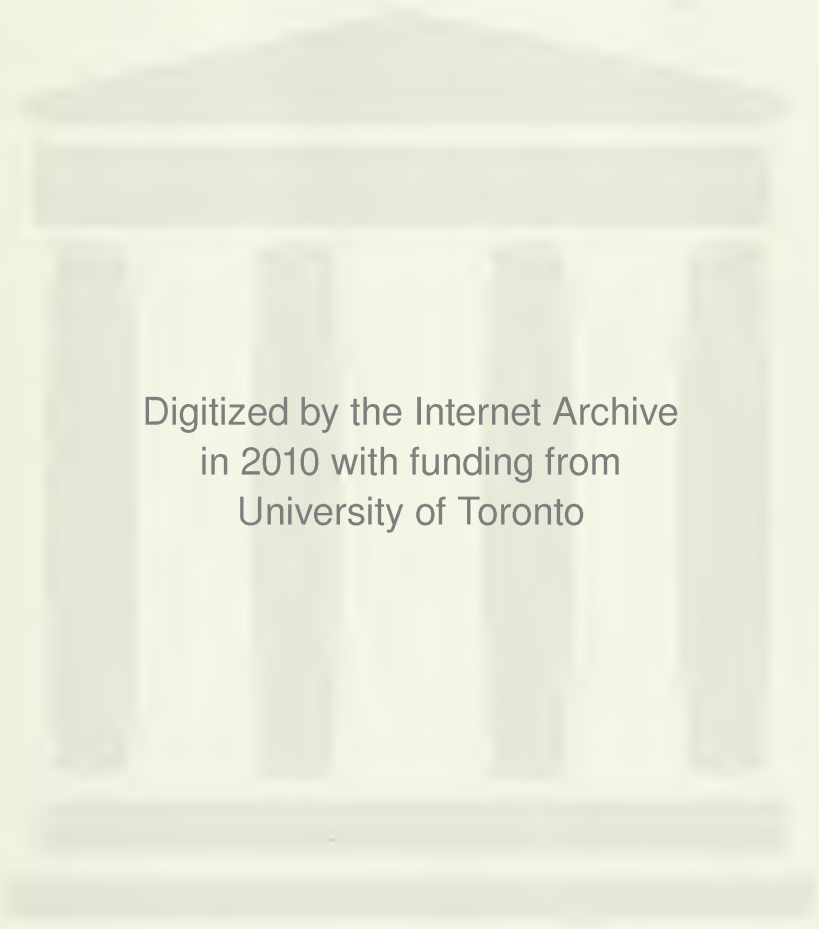

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Important Developments in Nitrogen Fixation

IT is now apparent that our requirements of ammonia and nitrates to be used in the manufacture of explosives for our army and navy have been greatly underestimated, and that the gravity of the situation which has been slowly but surely approaching has not been realized by the majority of the Government's advisers.

Important developments have recently taken place. In spite of the fact that our imports of Chile nitrate have increased enormously during the last two years—and our production of by-product coke ammonia has also increased to an enormous extent—the Government finds itself facing a serious shortage of ammonium nitrate. The Ordnance Department has consequently appointed the Air Nitrates Corporation its agent to construct and operate an immense plant at Muscle Shoals, Ala., to manufacture ammonium nitrate by the cyanamid nitrogen-fixation process. The arrangement is unique in Government affairs. The officers of the new company are at the head of the American Cyanamid Company and the services of that company's entire organization have been patriotically offered to the Government in connection with the project. Work is already under way on this new plant, which is entirely independent of the small plant now being built at Sheffield, Ala., to use the synthetic ammonia process recommended early in the fall by the Nitrate Supply Committee. Power will be obtained from the Alabama Power Company, pending the completion of the power plant, which is part of the hydroelectric development. In the meantime about 30,000 horse power will be supplied from the hydroelectric plant of the Alabama Power Company and 30,000 more from a steam plant now being constructed. Shipments are expected from the plant in six months.

It will be remembered that Congress appropriated $20,000,000 in June, 1916, for nitrate supply. A Nitrate Supply Committee was later appointed by the Secretary of War to investigate various sources and processes of production of nitrates and nitric acid. We published the final recommendations of this committee a few months ago. They were, in brief, that a 30-ton per day synthetic ammonia plant should be constructed to use the General Chemical Company process and that an ammonia oxidation plant be constructed to produce 12 tons of nitric acid per day. Appropriations were also recommended for experimentation with other processes

and it was recommended that 500,000 tons of Chile nitrate be accumulated as a reserve. Following these recommendations work was started on the synthetic ammonia plant, and is understood to be at present in progress. It is plainly evident now, however, that this source of supply in its present stage is not considered a very large factor by the War Department.

In studying the Nitrate Supply Committee recommendations one gets the impression very clearly that we had no urgent needs for nitrogen fixation, as considerable experimentation and development work was provided for and only $3,600,000 out of the $20,000,000 was to be spent at once in building plants for producing 10,000 tons per year of ammonia and about 4,000 tons per year of nitric acid. The cyanamid process was not mentioned in the final recommendations.

It will be remembered that Mr. Washburn, president of the American Cyanamid Company, offered in 1915 to build a $30,000,000 plant on a suitable water-power site to make nitric acid for war needs and fertilizer in peace times. He had been requested by the War Department to present a scheme for nitrogen supply, and his ideas were published by us in April, 1916. Muscle Shoals was considered by many the ideal site for such a plant, and this dream is shortly to be realized. It was also very clearly brought out by Mr. Washburn that coke-oven ammonia could not be depended on to furnish us with ammonia for making nitric acid and nitrates in case of war. He showed that this ammonia was completely consumed in industries from which it could hardly be withdrawn without great damage in case of war (37 per cent is used in cold storage, 10 per cent in explosives and chemicals and the balance in fertilizers). We quote Mr. Washburn as follows:

> Germany, the greatest European country in metallurgical industry, producing 90 per cent of her coke supply in by-product plants, turned to atmospheric nitrogen for her war requirements. . .
>
> One of the serious limitations upon the growth of the by-product coke oven is the relatively great investment involved therein. ($100,000,000 required to produce ammonia sufficient to make 180,000 tons of nitric acid per annum.) Notwithstanding these facts some enthusiasts have suggested that coke ovens could be erected wholesale in times of war.

These developments bring out two facts. First, that our needs have been greatly underestimated by the majority, and second, that in time of war quick action is needed and no time can be lost in experimentation or indulging in fascinating possibilities. The Government's decision does not discredit in the least the General Chemical Company's process nor the excellent work done by the Nitrate Supply Committee. It appears, however, that they greatly underestimated our needs and the necessity for quick action, and failed to recommend the use of the "bird in the hand," the cyanamid process, which had been thoroughly proved on an immense scale and was already well understood by American engineers. The reader is referred to Nauchkoff's article in our issue of Nov. 1, 1917, which shows the nitrogen resources of the warring nations very clearly and the part the cyanamid process plays.

It may be perfectly true that the synthetic ammonia process with subsequent oxidation of the ammonia to nitric acid would be the most desirable from several standpoints in the long run, but many large-scale problems have yet to be met, and we have no time to wait. If the war continues any length of time we can use more than the output of both the synthetic ammonia and the cyanamid plants. Mr. Washburn estimated in 1916 that a plant such as is now being built at Muscle Shoals would produce the equivalent of 180,000 tons of nitric acid per year. We are not permitted at present to go into further details as to the Government's needs and the new plant, but we have very good reasons to believe that even this plant will be inadequate to meet our needs in a short time, so rapidly are they increasing.

Review of Gold and Silver Metallurgy

IT is now a year since we commented on the anomalous position of the gold producer in this era of advancing prices. More recent events have accentuated these conditions; doubly so, perhaps, because long-delayed prosperity came to the relief of the silver miner.

The high commodity prices and acute labor shortage prevalent throughout the world have borne heavily upon the gold miner, who, unable to recoup his expenditures by advancing the price of his own wares, has been at a disadvantage in competing in the labor market. Similar conditions are reflected in all our news from abroad, and Canada, Australia and South Africa are alike suffering from an insufficient supply of labor. T. T. Read recently summarized the situation in a pleasing phrase to the effect that we have passed from the position of buying labor to selling employment.

In such circumstances it is but natural that the past year has been marked by a singular lack of activity in the development of new processes and the erection of new plants. In general, it may be said that the metallurgist's attention has been engaged by collateral lines of activity rather than by those directly affecting his specialty, but always with their extension and future application in mind.

Thus his interest in grinding machinery and in flotation has continued. In a measure he has accepted the ball mill as standard practice, if we may so interpret the new mills at Oatman and the remodeling of the Dome plant. Parenthetically, it may be noted that ball mills crushing in cyanide solution and followed by fine-grinding machinery, Dorr counter-current decantation and Merrill precipitation equipment, constitute the modern plant. This flow-sheet indicates the discarding of amalgamation, and in such circumstances at least the ball mill seems to be the logical machine. Where amalgamation is to be retained in the scheme of treatment the matter is not so clear, since the "inside amalgamation" of the stamp mill cannot well be supplied to the ball mill by reason of difficulties of clean-up. It is our impression, however, that this objection need not be of serious import, since this "inside amalgamation" tends primarily, by its vigorous churning or mixing of quicksilver and pulp, to collect and amalgamate the extremely fine gold particles in the "slime" portion of the ore—the very particles that may be expected to yield most readily to secondary treatment.

There have been no radical changes in the mechanical equipment of the latest mills; the machines commonly in use for classifying and dewatering are, however, undergoing constant refinement. It is rather interesting to note that whereas mechanical classification is gradually supplanting hydraudic classification in gold and silver milling, a new design of cone, apparently a distant relative of the diaphragm cone of South African practice, is enjoying a certain popularity in the copper districts of the Southwest.

Extreme simplification of the flow-sheet may be leading us to unnecessarily fine grinding: separate treatment of sand and slime is no doubt more often justified than practised.

Flotation has progressed during the year, and in the direction indicated by an examination of its nature and limitations. At Cobalt and in the San Juan it has been of great value. It finds its best opportunity where, in addition to gold and silver, the ore contains sulphides or similar base-metal minerals in commercial quantity; it is least likely to win favor when its product must compete with high-grade bullion, salable to the government without discount. A chapter in Rickard and Ralston's recent book makes an interesting presentation of this phase of the process.

The method of cyanide production proposed by Bucher has attracted much attention. This process, it will be recalled, depends upon the reaction between carbon, sodium carbonate and nitrogen, at a temperature of 900 to 1000 deg. C., using finely divided metallic iron as a catalyzer. Clevenger has suggested what was no doubt in the minds of many others interested in gold extraction—that the cyanide so formed could be taken up at once in works solutions, thus obviating all concentration of the extract.

Bucher's process, unlike another chemical proposition which, a few years ago, gained much publicity in the technical press, lends itself to verification in the hands of others than its inventor. It makes cyanide, and the cyanide it makes, obtained in solution as Clevenger proposes, will extract gold.

Upon examination, it must be confessed that the proposed application loses some of its appeal. Certainly it would be a comfort to have a supply of cyanide always at command, but many an already overburdened millman might well demur to the assuming of one more duty. However this may be, we look for cheaper cyanide in the future, and we hope to see it offered by several new American manufacturers.

Indeed, the general development of America's chemical industries promises excellent things for the future. Zinc dust is now made at several American plants, production no doubt being stimulated by the prevailing prices, which have been firmer than the spelter market would seem to have warranted. The quality of some of these brands is most excellent, and it seems improbable that the German dust will ever command its earlier favor.

Simultaneously with improvement of the precipitant, the technique of precipitation has been refined and developed. The former limitations of the process have undoubtedly been widened. Greater efficiency has been obtained and consequently a higher grade product is now the rule.

Zinc-dust precipitation was already dominant in this country. It will be interesting to observe whether the method will eventually replace the zinc-shaving process from its great stronghold in South Africa. It is conceivable that the sum of several minor improvements such as we have mentioned may finally throw the scale.

The many recent advances in the metallurgy of zinc are of especial interest to the cyanider, who requires the metal in his operations and must perforce tolerate it in his precipitates. In addition to the development of precipitation methods, we may see a revival of the proposal made some ten years ago—to distill the zinc from the precipitates, recovering it for further use.

It seems inevitable that improvements tending to increase the precious-metal content of precipitates will favor the introduction of the electric furnace for refining.

Metallurgy of Zinc in 1917

IT may be said that as zinc was the first metal to be affected by the war boom in metals, so it has been the first to be affected by the deflation consequent upon overproduction, and decrease of consumption due to artificially high prices. The end of the year 1916 saw a marked tendency in this direction. Production was even then already outstripping consumption, and profits were showing a corresponding depreciation. During 1917 the increasing cost of coal and gas fuel, together with the relatively higher cost of ore, has forced such a curtailment of output that at the end of this year we have a condition where only those plants having by-products of value, such as sulphuric acid, can show what even in pre-war days would have been considered a fair profit.

These remarks concerning commercial conditions are made only to call attention to the principal reason for what is apparently a lack of progress in zinc metallurgy during 1917. At a time when the less profitable plants are being shut down and when even the best plants are being forced to pass dividends, it is hardly to be expected that much new capital would be invested in improvements other than those absolutely necessary to meet the increased competition of the time.

The period of exorbitant profits during 1915 and 1916 has not been without its advantages, aside from the large returns paid by most of the smelting companies. New plants were constructed and older ones were enlarged and improved, and these improvements, in regions other than the gas belt, have been of such a character as the industry had not hitherto witnessed. In fact, most of the construction east of the Mississippi River is now such as to give great hopes for a commercially sounder basis for the industry, besides assuring relatively lower costs of production and better recoveries upon a return of normal conditions for labor and supplies.

As the year 1917 brought curtailment of smelter ca-

pacity instead of the expansion to which we had become accustomed, and brought even greater curtailment of profits to most of the smelting companies, so, as might be expected, improvements in the art have not been marked. Attempts have necessarily been made to meet higher labor costs with mechanical devices to increase the tonnage handled per man, and in minor items this has been more or less successfully accomplished.

Outside of the gas fields of Oklahoma and Kansas, practically all zinc sulphide ores are roasted with a special view to the conversion of the sulphur gas to sulphuric acid. For this purpose the roasting furnaces used in American practice have been almost invariably of the Hegeler type. Attempts have been made to introduce furnaces of the Spirlet or of the Wedge type, and such furnaces are, in some cases, in actual operation, but as yet there is no evidence of a desire on the part of operators in general to abandon the better established apparatus.

In the actual operation of the retort furnaces it would seem that there might be much room for labor-saving devices, especially in view of the increased cost of labor. In a few isolated cases mechanical devices for discharging and recharging the retorts are actually in use, and the operators of such devices seem pleased with the results obtained. But again it is to be noted that notwithstanding the present most favorable conditions their use is still confined to a very few plants, and most zinc metallurgists continue to look upon them as interesting experiments which may some day be worth investigating.

The metallurgy of zinc, as practised today in the older retort process, has been of slow growth, and is the result of many years' accumulated experience. The financial path of zinc metallurgy may be said to be marked by the tombstones of defunct processes. It has only been of recent years, especially since the metallurgist has been confronted by the necessity of smelting lower grade and more complex ores, that there have been any encouraging signs that new conditions might bring out new methods to meet them. The necessity for handling complex ores, low in zinc, especially those common in the Rocky Mountains, coupled with the abnormal demands for spelter of a great degree of purity which has accompanied the war conditions, has given the opportunity for the development of an entirely new process in zinc metallurgy.

Previous to the present year the production of electrolytic zinc had been measured in a few tons per day, and had taken place mostly on an experimental scale. During this year, however, the production of zinc by electrolysis may be said to have passed from the experimental to the commercial basis. The longest step taken, of course, has been that at Great Falls, although a number of other plants have come in with tonnages which, while much inferior to the output of Great Falls, are, nevertheless, of considerable magnitude.

It is, perhaps, too early yet to say just in what direction this new art will work out to the greatest advantage. The operations at Great Falls involve wet concentration of the ore to a high-grade product, followed by roasting and leaching of the concentrate. This results in a residue containing a considerable amount of zinc, and attempts have been made to smelt this material in a reverberatory furnace, whereby the zinc is volatilized and a commercial quantity of the other metals collected in the form of a copper matte.

The work now being done on Colorado ores by another company, having an electrolytic refinery at Keokuk, Iowa, is carried out on lower grade and more complex ores. These are partly roasted, then smelted directly in a reverberatory furnace. By this means the lead and zinc are separated in a relatively pure form from the gangue of the ore, and the other metals are concentrated in a matte. The zinc and lead concentrates are then shipped to the refinery for separation.

The plant at Park City, Utah, follows, in general, the Great Falls practice of roasting and leaching, with the addition of revolving cathodes in the electrolytic tanks. The plant at Mammoth, California is operating on a complex baghouse product produced from the smelting of copper ores. This material has as its principal constituent zinc as sulphate, but has many other metals present, tending further to complicate an otherwise not simple process. The successful working out of this problem will reflect much credit on the men in technical charge of the work.

Direct electrothermal smelting of zinc ores seemed at one time to be approaching success. Much interesting and more or less successful work along this line was carried out at Hartford, Conn., a few years ago, but thus far the process has not come into commercial use. A plant is now being built by the Guggheim interests at Pueblo, Col. In Norway, plants have been operating some years on such a method, but there the cost of power is lower than anything we have or are likely to have in this country.

Copper Metallurgy in 1917

"GET the Copper" has been the slogan of the producers during 1917. During the first part of the year there seemed to be an unlimited market at very fancy prices—published quotations for spot metal ranged from 29 to 37 cents, then falling back to 25½ cents while the price-fixing program was awaited. Considerable copper changed hands at these figures, even though the bulk of the production was absorbed by the Allies at figures substantially lower, down to one large sale to the American government at about 16.7. The spot prices were evidently so excessive that the efforts of the administration were early turned toward fixing a price for the red metal, which was agreed upon Sept. 20, the official price being set at 23½ cents. This is a quite liberal figure, and one calculated to allow even the most unfavorably situated company to produce at a profit, although later many smiles were provoked by the attempts of brokers and other spokesmen to explain the profound riddle, "When is a low-cost producer, and why?"

The high price and scarcity of machinery and construction materials has not halted a universal extension in plant capacity. While only one notable new

smelter is under construction in the Western States—that of the United Verde Extension, building near Jerome, Ariz.—one can hardly mention a plant in that region which is not engaged in a construction program of considerable magnitude preparatory to a larger output of blister. One notable exception to this statement is the Great Falls plant of the Anaconda Copper Mining Company. Before the war broke out this smelter was one of the world's large copper producers. At the present time but little copper is made, and that merely as a by-product of their zinc plant, recently completed.

These efforts toward maximum production have been more than nullified, however, by an epidemic of labor troubles which seemed to infest the copper mines, smelters and refineries. Strikes of various degrees, intensity and duration spread from one location to another, completely paralyzing the activities of whole districts for as long as five months. These differences have now been largely settled—in some cases by a federal commission working apparently on some such theory as this: "The management and men must come together and resume production; the men will not compromise, therefore the management must."

The significant feature in reverberatory smelting is that oil is becoming too rare and valuable to be used as a fuel, and is to be supplanted by powdered coal. This change has already started. Side-charging of fettling or calcine through numerous holes at the skewback is almost universal. An interesting modification of this plan is that devised by Heggie, where manger-like openings through the side walls are constantly heaped with cold charge. This latter idea has brought about a most interesting and important evolution in buckstay construction, in fact, in the entire scheme of "ironing". a furnace.

In the converting department, the 13-ft. x 30-ft. Peirce-Smith converter mentioned in our review of last year, has amply demonstrated its efficiency, and is being installed in several American Smelting & Refining Company plants. This converter is structurally far superior to the smaller styles, and has established some enviable metallurgical records. Only the long-suffering converter crane-man could fully appreciate the clear air in the El Paso converter aisle, where some real hoods fit closely over the mouths of these new converters. Converter capacity has been materially increased by the common use of a silica gun. This device is merely an air-jet blowing a continuous stream of crushed siliceous material through the end of the converter during its operation. This saves the time of converter and crane necessary to charge this material by boat or chute; further, it facilitates uniform operation at a lower temperature, thus increasing the life of the basic lining. Everyone is still talking about that metallurgical nuisance, converter slag, but nothing new has been done about it. Multi-stage turbo-blowers, both of the Ingersoll-Rand and the Rateau-Bottu-Smoot design, are now quite common in power houses, replacing the bulky blowing engines used to compress converter air.

In copper hydrometallurgy, the successful operation of the New Cornelia plant at Ajo, Ariz., is a matter for congratulation to the metallurgists who worked out the possibilities of the process, and the capitalists who financed this new undertaking. A beautiful process and a beautiful plant! There is, however, one unsolved problem in these leaching processes, that is to say, the treatment of that very considerable percentage of solution which must be "bled" from the circulation to prevent undue accumulation of iron and other metallic impurities. At present the copper in the waste Ajo solution is precipitated on iron, but, as compared to the electrolytic room, these dirty vats seem extremely antiquated. In this connection it would be pertinent to point out that the price of iron scrap is steadily rising, while the prophesy that the easy production of sponge iron from concentrates will take first place as a precipitant seems yet to be fulfilled.

The general interest taken by copper metallurgists in their possible by-products is a good omen—even recent investigations on smelter smoke point to its value as an actual fertilizer. The general production of arsenic from flue dust in normal times served only to glut the market, but these plants are now working to capacity. Sulphuric acid plants are becoming so common as to fail to excite much interest. The old-school metallurgist, however, can hardly recognize that corner of the smelter where potash alum, zinc sulphate, zinc chloride or liquid sulphur dioxide is produced by the ton. Some few of the Western plants seem peculiarly well adapted for the production of brass munitions. Large quantities of electrolytic copper and zinc, ample coal and electricity, an energetic staff and adequate labor supply—this is a conjunction of factors, any one of which is becoming rarer in the Eastern States. In stress of war the past objections to this development, such as lack of market and high labor or freight rates, are either becoming less cogent or disappearing altogether. Eventually, of course, the West will absorb enormous quantities of locally-produced metallifactures; the war may easily hasten the establishment of some of these factories close to the point of production. The construction of a rod-mill of considerable dimensions at Great Falls, Montana, seems an earnest of such near-by developments.

Flotation in 1917

THE interest in flotation has now passed its zenith and the process has become too common a thing to attract the interest that it did while young in its application to American conditions. For the past two years the various hydrometallurgical schemes have had to be set aside more or less to allow the full development of flotation before it was deemed safe to proceed with the more expensive hydrometallurgy. Interest is again beginning to center around the hydrometallurgy of copper, zinc and lead, in addition to the revival of older forms of the hydrometallurgy of silver and gold. The copper hydrometallurgists are reputed to have expected flotation to make leaching of copper from low-grade ores unnecessary, and were expecting to devote their

energy to the hydrometallurgy of flotation concentrate. It now seems certain that flotation will not be the complete solution of the treatment of low-grade oxidized copper ores, and that hydrometallurgy will come back to its own.

The various schemes for the flotation of oxidized minerals have been further tested and found wanting, for a number of reasons. In the first place, most of them are very likely to be spoiled by the appearance of ore of a slightly different composition than that for which they had been designed. For instance, it has been found that the oxidized ores of lead which can be sulphidized and floated are few in number, and that the great majority contain materials which consume the sodium or hydrogen sulphide used for sulphidizing. Such things as basic sulphate of iron or manganese dioxide are of common occurrence in oxidized ores, and tend to prevent good sulphidizing. So while there are undoubtedly a number of ores which can be successfully sulphidized and floated, the method does not present a universal solution of the problems involved. Probably methods will be found for neutralizing the "sulphidicides" just as they were slowly developed for neutralizing "cyanicides" during the growth of cyanidation.

The flotation-oils situation is no longer so acute, as it has been found that there is a great variety of oils which will yield acceptable flotation results, although the best ones are very hard to obtain. A number of scareheads have appeared announcing the value of one or another nostrum for such work, but few of them have resulted in anything. Such has been the fate of shale oil and the products from destructive distillation of gilsonite and similar hydrocarbons.

Greater interest has centered around the various proposals which have been tested in attempting to escape the terms of the patents of the Minerals Separation Co. A number of the larger copper concentrating mills and one or two of the zinc mills began using more than 1 per cent of oil on the weight of the ore, 1 per cent having been said to be the approximate point below which a new effect was produced and for which the Minerals Separation Co. had been able to obtain patent. By the use of as high as 3 per cent of oil in commercial frothing-flotation work it seemed to be very definitely proved that there was no "critical proportion" of oil. This argument formed the basis of the defense in the new lawsuit brought by the Minerals Separation Co. against the Butte & Superior Co. in the Circuit Court at Butte. Nevertheless, the Minerals Separation Co. won the decision, and it has now been appealed and will shortly be tried in the higher court.

With regard to the patent situation, we have wearied of following its details. The stakes are too high for any of the parties involved to give up the fight, and the plaintiff company has changed front repeatedly in trying to claim the whole field of flotation. We have now lost all hope of a satisfactory end to this litigation, and think it not unlikely that the life of the patents will expire before the litigation ends.

Flotation is now in commercial operation in a number of mills for the concentration of molybdenum ores in Canada and in Colorado. The details of its application apparently have been worked out to a satisfactory state for elemental sulphur, such as is found in low-grade sulphur ores, and for alumina resulting from the calcining and leaching of alunite ores in southern Utah. We do not know to just how many new uses the process will be put, but it seems safe to say that there will doubtless be more new applications as time goes on. Taken as a whole, we do not believe that the total tonnage of material treated by flotation processes will increase beyond the tonnage anticipated in 1918. There is a natural limit to everything, and advocates of flotation can well point with pride to the fact that the process is now being used on a greater tonnage of material than is any other metallurgical process outside of the concentration and smelting of iron ores.

Iron and Steel in 1917

THE iron and steel industry underwent startling changes during the year just closed, but in that it was true to character. The year opened with a continuance of the runaway market that had characterized the greater part of 1916, and when through Germany's declaration of ruthless destruction of merchant shipping on February 1 it became apparent that war was practically inevitable the market began to advance still more rapidly. The actual declaration of war on April 6 was followed by further advances, but the character of the market changed. It had long been realized that whenever the European war should end there would be a complete readjustment in iron and steel prices, while with the entrance of the United States into the war it was recognized that an advancing iron and steel market could not continue for an indefinite time. Buying for far-forward deliveries soon ceased, therefore, but that only left the prompt-delivery market freer to advance, and by the end of June a price-level had been reached that cast altogether in the shadow all previous market attainments. The prices at which sales were then being made were approximately double the average prices at which material was being shipped. It became obvious that buyers would be unable to pay these prices on the entire tonnage required. Some were making specialties that enabled them to pay almost any price. Others had relatively low-priced material being delivered to them, and paid the fancy prices only on such small tonnages that their average cost was not greatly increased.

On July 12 President Wilson made his famous appeal to miners and manufacturers that they should "forego unusual profits" and that there should be "one price for all," the Government, its Allies, and the general trade. The iron and steel trade did not seem to adopt the idea with much readiness. Apparently it was not gifted with its usual foresight, but there is reason to suppose that it foresaw the inevitable but could recognize no particular necessity for the existing trade being disturbed. The trade was running under such steam that it had a number of months still to go. Meanwhile no one would suffer particularly, and the Government intended to lay heavy war taxes upon

profits of the entire year 1917. In due time, namely on September 21, the iron and steel trade yielded gracefully to the President's requirements and then made it almost a religion to carry out the price agreement in both letter and spirit. There have been a few recalcitrants, but only a very few indeed. By agreement with the manufacturers, the War Industries Board announced on September 24, October 11 and November 5 certain prices for iron and steel products, while the price-setting for various other commodities was left to the American Iron and Steel Institute, with the understanding that all prices should be in harmony, considering costs, with the basis prices originally set.

The industry has found itself under obligation to furnish a great deal more iron and steel, for the best prosecution of the war, than was originally expected. The early estimates made, say from February 1 to July 1, all referred to material that would be required directly as war munitions for the Government and its Allies. These estimates ran, generally speaking, from 20 to 40 per cent of the output. Afterwards an altogether new viewpoint had to be developed. As President Wilson insisted in his appeal of July 12, although he did not mention any particular commodity, no clean distinction could be drawn between material required directly for war and material merely contributing more or less indirectly towards winning the war.

This fact became clear as to iron and steel. As the country from month to month reached a fuller realization of the industrial forces it would have to mobilize for prosecuting the war to the fullest extent, it was found that the few iron and steel-consuming industries that could not contribute were losing in activity of their own accord, while the great majority of the consuming industries could directly or indirectly aid in prosecuting war. Thus the capacity of the railroads was found to be strained, and more rolling stock, particularly locomotives, is obviously required. Maximum petroleum production is essential, requiring the fullest supply of oil-country tubular goods. The automobile factories, while consuming much less steel for making pleasure cars, are required to make many more trucks, in which heavier steel is used, as, for instance, light plates instead of blue annealed sheets. The one industry that seemed marked for decreased iron and steel consumption, without any compensating increase, the so-called building industry, has largely disappeared without leaving a gap, and yet it has had some special activity. The lettings of fabricated steel in November were heavier than in any of the eleven months preceding, and the lettings were almost entirely in connection with the war.

This complete change in the character of iron and steel activities occurred through the overriding of obstacles that had been considered difficult if not insurmountable. The iron and steel-consuming industries had been regarded as so specialized that only a limited portion of them could be employed for war activities. The iron and steel finishing departments were regarded as so specialized that they could convert only a limited proportion of the crude steel into forms suitable for war purposes. In both cases the specialization had to yield. Factories had to be converted to make war products instead of peace products, and the steel-finishing industry had to go through its own changes. The tradition was that the steel industry had to put such a percentage of its output into merchant bars, such a percentage into plates, and so on. The production in 1916 of sheared plates, ¼ in. and heavier, was only a trifle over 1,800,000 gross tons. Additional plate mills were built and the capacity approximately doubled. The slabbing mill output was entirely absorbed and a large tonnage of blooming-mill slabs is being employed. What has helped materially is that so large a tonnage of steel is required for shells, this steel being chiefly the product of the blooming mill, which thus becomes a general service mill. The supply of sheet bars has been somewhat limited, but the war requires the entire output of the tin mills only, and but a part of the sheet-mill output, and thus the end of 1917 found the tin mills operating full and the sheet mills operating at 50 to 60 per cent of capacity, with everyone moderately well satisfied.

At all times the iron and steel industry has been able to furnish all the iron and steel that could profitably be employed in the work of waging war. The changes required of the consuming industries have been occupying the time. It is a remarkable thing that when the steel industry has been so highly specialized it has been possible to respond so fully to the completely new alignment of demand. That it has been able to do so has been due to the fact that the consuming industries were likewise specialized, and had to undergo their changes.

The iron and steel industry is in position to furnish much more material than hitherto, if it is provided with adequate transportation facilities. It produced 39,400,000 tons of pig iron in 1916, operating its available furnaces practically at capacity, but at the close of 1917 it had capacity equal to 42,000,000 or 43,000,000 tons of pig iron, and had produced only about 38,750,000 tons in the year. There was, and is, a lack of sufficient transportation for Connellsville coke. In steel ingots the 1916 output was 41,400,000 tons and the 1917 output about 42,500,000 tons, but the capacity is nearly if not quite 50,000,000 tons. There have been shortages of pig iron, coal and scrap, due to insufficient transportation.

Taking only 45,000,000 tons as the ingot capacity of the United States, the Allies now have, with Canada, Japan, Italy, France and England, a total steel ingot capacity, actually operative, of close to 65,000,000 tons. The Central Powers started with about 19,000,000 tons in Germany and 4,000,000 tons in Austria, while Belgium's 2,500,000 tons capacity was captured and about 3,500,000 tons of the French capacity, making a total of about 29,000,000 tons, all of which cannot be operated. Steel will win the war, and the first American soldier to give his life on the western line was in the Minette iron-ore district, with the great French and German steel-producing districts before him.

The Western Metallurgical Field

Burro Mountain Concentrator

The Burro Mountain branch of the Phelps-Dodge Corporation has been operating a 1500-ton concentrator at Tyrone, N. M., since April, 1916. The ore, which is recovered from underground workings, consists of disseminated sulphides of copper and iron in a monzonite porphyry, and contains about 2 per cent copper. At present the tailings run approximately 0.5 per cent copper, of which half is copper as oxide. Experiments are now in progress to determine whether additional flotation machines will not reduce the tailing loss.

Water for milling is derived from the mine pumpage, which amounts to about 750 gallons a minute. Tank outflows are returned to circuit by properly placed pumps, and in times of water scarcity some of the water in the tailings ponds is pumped back by centrifugals.

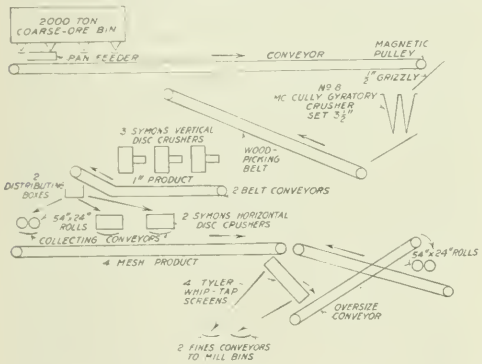


DIAGRAM OF CRUSHER SECTION, BURRO MOUNTAIN MILL

The mill is entirely electric driven, individual motor-drives being used for the most part. About 750 hp. is furnished from the main power plant near the mine, where Diesel oil engines are installed.

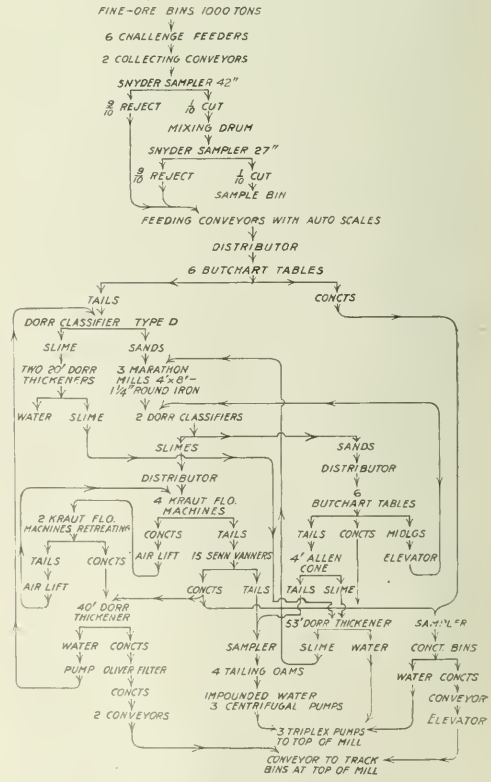
Through the kindness of Mr. J. T. HALL, mill superintendent, we are enabled to present the accompanying flow-sheet. It will be noticed that the crushing division reduces the ore to 4-mesh (Tyler Standard), which is fed directly to a battery of Butchart tables without sizing or classification. Indeed the only sizing done throughout the mill consists of a rough classification in the de-watering drags, where the overflow is called "slimes," and the de-watered material is called "sands." The tailings from the flotation machines run over a battery of Senn vanners, which catch the coarse, and considerable of the very fine, sulphides which did not float. The table and vanner concentrates are settled in rectangular wooden tanks at the bottom of the mill, which tanks are emptied through plug-openings in the bottom, discharging their contents to a belt conveyor which leads to a track at the top of the coarse-ore bins. A spur to the bins is now under construction, and later the concentrates will be delivered directly by belt conveyor to a box-car loader. This material is shipped to the Copper Queen Smelter at Douglas, Ariz., for treatment, about one-fifth of the entire output being a flotation concentrate.

The mill itself is situated on a steep side hill, and all repair parts are delivered on tracks at the topmost level. An incline railway, used during construction, is still in constant use. The carriage on this incline takes push-cars from level to level, where tracks lead directly into each floor of the mill and the various shops. A large jib crane is installed at the dock on top of the hill to handle heavy parts from the railway cars to the incline.

Evolution of Reverberatory Construction at American Smelting and Refining Co. Plant, Hayden, Ariz.

The American Smelting and Refining Company's smelter at Hayden, Ariz., was blown in May, 1912, for the treatment of the concentrates produced by the neighboring Ray Consolidated concentrator and such other custom ores as might present themselves. Originally a two-reverberatory plant, the receipts of smelting material were almost continually in excess of the capacity, until at present the company is installing the fourth reverberatory, 24 ft. by 114 ft. in dimension, oil-fired, and with the usual waste-heat boilers (1500 hp.) and other auxiliaries.

The construction of these furnaces has undergone an interesting evolution. Originally built almost as copies of the successful old Garfield long reverberatory, with a multitude of small buckstays ranged on sides and ends, the firing ends of the first two furnaces were rebuilt to allow side charging through mangers, accord-



FLOW SHEET OF ONE UNIT OF CONCENTRATOR, BURRO MOUNTAIN MILL

ing to the ideas of James Heggie, general superintendent of the El Paso plant of the A. S. & R. Co. This involved piercing the side walls with broad, arched openings, requiring a buckstay-spacing of about nine feet—the thrust of the roof arch being carried by a heavy horizontal girder.

This construction proved to be satisfactory in all respects, and the third reverberatory was accordingly ironed in a similar manner throughout its length, replacing the multitude of small I-beam buckstays by the largest H-beams, in combination with horizontal girders behind the skew-backs to carry the roof thrust. At the same time the arch was carried full width to the skimming end of the furnace, avoiding excessive scour on the bricks at this region.

The objection to this ironing is that it is hardly flexible enough. That is to say, in case of a failure of a portion of the arch between expansion joints, it is almost impossible to regulate the movement of the new section without large and undue distortions in the old roof. This has been corrected by the superintendent, Mr. R. B. GREEN, in the reverberatory now being built by placing a pair of buckstays opposite each expansion joint in the roof and subdividing the horizontal girder so that each section of the roof can be handled as a unit. With such construction a roof-failure can be replaced in a few hours and the furnace again smelting in the time formerly required to cool off the whole furnace.

Although the present reverberatories are oil-fired, the management has decided to replace this fuel with pulverized coal, owing to the increasing price and scarcity of oil. Construction of a 300-ton pulverizing plant has therefore been commenced.

The converter department has seen a corresponding increase in capacity. Originally containing two 10 ft. by 26 ft. Pierce-Smith shells, a 12-ft. Great Falls converter was soon installed to act as a standby. Construction of a large 13 ft. by 30 ft. Pierce-Smith is now under way to care for the matte produced by the added furnace capacity. The brick converter flue, 18 ft. 1 in. by 19 ft. 6 in., in cross-section (hopper-bottomed), will be extended south to a point of higher ground, where a new concrete stack 16 ft. diameter by 250 ft. high, will be built. This will replace the present temporary stack, a square steel skeleton lined with corrugated iron.

When these additions are completed, which will be about July 1, 1918, the Hayden smelter will smelt approximately 2000 tons of charge daily and ship a monthly production of 10,000,000 pounds of blister copper.

De Spirlet Kilns at Argentine, Kans.

The National Zinc Company has been operating zinc blende roasters of the De Spirlet type for about two years, and at the present time has a battery of ten of these kilns in operation. As has been noted in METALLURGICAL & CHEMICAL ENGINEERING, Sept. 1, 1917, page 220, these roasters consist of a succession of round superposed, flat arches, which are alternately fixed or rotating. Rabbling is effected by fire-clay blocks projecting from the roof of the individual hearths. Thus, the top arch forms the roof of the top hearth, and is stationary. The next arch rotates and forms the floor of the top hearth and the roof of the next-to-top hearth; the next is stationary, and so on.

The hearths themselves, 12 ft. 10 in. in diameter, are built within a ring of suitable steel shapes. This ring is placed on a floor and a centering of sand swept up using the familiar pivot and sweep of the loam mold. The bricks, 5 in. thick, are all special, with a key extending around the edges. It has been found that extreme care in matching these bricks for a minimum clearance at the joints will prolong the furnace campaign from four months to a life of one year. Four brick masons complete an arch in three days.

An annular trough of bent angles is riveted to the periphery of these flat arches, which is filled with roasted ore and acts as a seal. Into the channel filled with granular material projects the downstanding leg of another bent angle riveted to the bottom of the corresponding channel just above. This sand seal effectually closes the joint between fixed and moving hearth. The fixed arches are hung from brackets at four columns.

These same brackets each carry a flanged wheel upon which the moving arches rotate. The track consists of the side of a bent railroad rail, to the base of which are bolted segments of a gear, meshing into a motor-driven pinion at one column. The individual arches are assembled into a furnace by traveling crane.

The hearths themselves are quite shallow, hardly 12 in., top to top; while the rabbles clear the bed only 1¼ in. The top hearth acts mostly as a dust chamber, the SO_2 gases being drawn off into collecting flues at the periphery. The ore is automatically charged near the center of the stationary roof and soon is worked through a hole at the center of the rotating bed. The rabbles of the second hearth work the ore toward the periphery, dropping to the bed below, thence to the center, and finally into two hoppers at the edge of the bottom hearth.

The base of this hearth forms the roof of a similar muffle which is heated by a coal flame, the products of combustion being drawn downward through ribbed iron flues to a chimney opening. Air for the roasting of the ore is preheated by being circulated around the cast-iron chimney flues and thence through a muffle just below the combustion chamber. The hot air is then introduced into the drop hole of the lowest ore hearth, and travels in a direction opposite to that of the ore. The SO_2 content of the gases is remarkably uniform, standing at 7 per cent ± 0.5 per cent for hours together. Dusting is extremely low, being only about 4 per cent when working on flotation concentrates. A treater is being installed to precipitate all of this finest dust, in order to clarify the acid made from the smoke. The recovered flue dust is converted into zinc sulphate.

One man tends the three furnaces, his only duties being carefully to loosen accretions from the fireclay rabbles from time to time. Coal consumption is 1 ton ± per furnace. Each furnace treats about 7800 lb. of green ore plus about 1800 lb. spiles, this being average capacity for a full campaign.

The engineers of the National Zinc Company have changed many features of the original De Spirlet design, and feel that real progress has thus been made. They are still experimenting on the furnaces to determine the characteristics best fitted for each individual ore at their disposal.

The Webb Export-Trade Bill.

AN important measure in Congressional legislation looking toward the establishment of American export trade is known as the Webb bill. It has passed both House and Senate, and it is expected that a Conference Committee will reach an agreement on minor differences when Congress reconvenes Jan. 3. The measure is so vital to American trade that we publish it herewith, with the Senate amendments numbered and italicized. The portions stricken by the Senate amendments are enclosed in brackets.

AN ACT

To promote export trade, and for other purposes:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

That the words "export trade" wherever used in this Act mean solely trade or commerce in goods, wares, or merchandise exported, or in the course of being exported from the United States or any Territory thereof to any foreign nation; but the words "export trade" shall not be deemed to include the production, manufacture, or selling for consumption (1) *or for resale,* within the United States or any Territory thereof (2), of such goods, wares, or merchandise, or any act in the course of such production (3) [or] manufacture (4), *or selling for consumption or resale.*

That the words "trade within the United States" wherever used in this Act mean trade or commerce among the several States or in any Territory of the United States, or in the District of Columbia, or between any such Territory and another, or between any such Territory or Territories and any State or States or the District of Columbia, or between the District of Columbia and any State or States.

That the word "association" wherever used in this Act means any corporation or combination, by contract or otherwise, of two or more persons, partnerships, or corporations.

Sec. 2. That nothing contained in the Act entitled "An Act to protect trade and commerce against unlawful restraints and monopolies," approved July second, eighteen hundred and ninety, shall be construed as declaring to be illegal an association entered into for the sole purpose of engaging in export trade and actually engaged solely in such export trade, or an agreement made or act done in the course of export trade by such association, provided such association, agreement, or act is not in restraint of trade within the United States, and is not in restraint of the export trade of any domestic competitor of such association.

And provided further, That such association does not, either in the United States or elsewhere, enter into any agreement, understanding, or conspiracy, or do any act which artificially or (5) [intentionally and unduly] *the natural effect of which enhances* (6) *or depresses* prices within the United States of commodities of the class exported by such association.

Sec. 3. That nothing contained in section seven of the Act entitled "An Act to supplement existing laws against unlawful restraints and monopolies, and for other purposes," approved October fifteenth, nineteen hundred and fourteen, shall be construed to forbid the acquisition or ownership by any corporation of the whole or any part of the stock or other capital of any corporation organized solely for the purpose of engaging in export trade, and actually engaged solely in such export trade, unless the effect of such acquisition or ownership may be to restrain trade or substantially lessen competition within the United States.

Sec. 4. That the prohibition against "unfair methods of competition" and the remedies provided for enforcing said prohibition contained in the Act entitled "An Act to create a Federal Trade Commission, to define its powers and duties, and for other purposes," approved September twenty-sixth, nineteen hundred and fourteen, shall be construed as extending to unfair methods of competition used in export trade against competitors engaged in export trade, even though the acts constituting such unfair methods are done without the territorial jurisdiction of the United States.

Sec. 5. That every association now engaged solely in export trade, within sixty days after the passage of this Act, and every association entered into hereafter which engages solely in export trade, within thirty days after its creation, shall file with the Federal Trade Commission a verified written statement setting forth the location of its offices or places of business and the name and addresses of all its officers and of all its stockholders or members, and if a corporation, a copy of its certificate or articles of incorporation and by-laws, and if unincorporated, a copy of its articles or contract of association, and on the first day of January of each year thereafter it shall make a like statement of the location of its offices or places of business and the names and addresses of all its officers and of all its stockholders or members and of all amendments to and changes in its articles or certificate of incorporation or in its articles or contract of association. It shall also furnish to the commission such information as the commission may require as to its organization, business, conduct, practices, management, and relation to other associations, corporations, partnerships, and individuals. Any association which shall fail so to do shall not have the benefit of the provisions of section two and section three of this Act, and it shall also forfeit to the United States the sum of $100 for each and every day of the continuance of such failure, which forfeiture shall be payable into the Treasury of the United States, and shall be recoverable in a civil suit in the name of the United States brought in the district where the association has its principal office, or in any district in which it shall do business. It shall be the duty of the various district attorneys, under the direction of the Attorney General of the United States, to prosecute for the recovery of the forfeiture. The costs and expenses of such prosecution shall be paid out of the appropriation for the expenses of the courts of the United States.

Whenever the Federal Trade Commission shall have reason to believe that an association or any agreement made or act done by such association is in restraint of trade within the United States or in restraint of the export trade of any domestic competitor of such association, or that an association either in the United States or elsewhere has entered into any agreement, understanding, or conspiracy, or done any act which artificially or intentionally and unduly (7) [affects] *enhances or depresses* prices within the United States of commodities of the class exported by such associa-

tion, it shall summon such association, its officers, and agents to appear before it, and thereafter conduct an investigation into the alleged violations of law. Upon investigation, if it shall conclude that the law has been violated, it may make to such association recommendations for the readjustment of its (8) [business, in order that it may thereafter maintain its organization and management and conduct its business in accordance with law] *organization, business, conduct, practices, or management in order that they may comply with the law.* If such association fails to comply with the recommendations of the Federal Trade Commission, said commission shall refer its findings and recommendations to the Attorney General of the United States for such action thereon as he may deem proper.

For the purpose of enforcing these provisions the Federal Trade Commission shall have all the powers, so far as applicable, given it in "An Act to create a Federal Trade Commission, to define its powers and duties, and for other purposes."

Passed the House of Representatives June 13, 1917.

Attest: SOUTH TRIMBLE, Clerk.

Passed the Senate with amendments Dec. 12, 1917.

Attest: JAMES M. BAKER, Secretary.

United States Tariff Commission Making Inquiry in Regard to Chemical Industries

The Tariff Commission is undertaking an inquiry into the significant developments that have taken place in the chemical industries since the passage of the tariff act of 1913. Changes which seem likely to alter permanently the conditions of international competition or the course or volume of foreign trade are to be special subjects of study.

All persons having direct knowledge of pertinent facts in regard to any particular industry or product are invited to submit a statement to the Tariff Commission. Among the matters on which the Commission desires as full and complete information as possible are:

1. The manufacture within the United States of articles formerly unavailable or obtained exclusively by importation, for example, phosgene.

2. In the case of industries previously established in the United States, the erection of new plants or increase in capacity of existing plants; for example, the increase in capacity of existing plants for making caustic soda and chlorine and the installation of such plants as textile and paper mills.

3. The future of industries or establishments newly created, or in which productive capacity has been greatly increased to meet a direct war demand. How can these plants be utilized when the war demand disappears? For example, the acetone industry.

4. Any general or significant differences in the prevailing method of manufacture in the United States and abroad, such as the relatively small use of the carburetted water-gas process in England compared to the process in the United States.

5. Differences in the organization of the industry in the United States and abroad.

6. The development or invention in the United States or abroad of new or improved processes which are likely to influence the conditions of international competition; for example, the hydrogenation of fatty oils or the flotation process for concentrating ores.

7. Significant changes in the conditions of international competition caused by the recent law making patents owned by citizens of enemy countries available to American manufacturers; for example, the patents on salvarsan.

8. Industries which have been seriously hampered in their normal operations or in their development by difficulty in securing materials or supplies formerly imported; for example, the lack of potash for fertilizer or glass. If these difficulties have been met by the introduction of substitutes, is it expected that there will be a return to the old materials and methods when foreign supplies again become available, or will the changes be permanent?

9. Developments or changes in other industries which have created a new or greatly increased demand for chemical products; for example, the manufacture of new varieties of glass in the United States.

10. The discovery of new uses of materials, creating a new demand or furnishing a market for materials formerly wasted; for example, the use of aniline as an accelerator in the vulcanization of rubber.

11. Any governmental hindrances in the United States or abroad, either in manufacture or commerce; such as the export duty on nitrate from Chile.

The Commission will publish only general statements or summaries, which will not reveal the operation or plans of individual companies.

Attorney General Interprets Laws Bearing on Importation of Distilled Spirits

In response to a request from the Secretary of the Treasury, the Attorney General has given an interpretation of the recent legislation on importation of distilled spirits. The food control act approved August 10, 1917, states: "Nor shall there be imported into the United States any distilled spirits." The revenue act approved Oct. 3, 1917, provides:

"That no distilled spirits produced after the passage of this act shall be imported into the United States from any foreign country, or from the West Indian Islands recently acquired from Denmark (unless produced from products the growth of such islands, and not then into any state or territory or district of United States in which the manufacture or sale of intoxicating liquor is prohibited), or from Porto Rico or the Philippine Islands. Under such rules, regulations and bonds as the Secretary of the Treasury may prescribe, the provisions of this section shall not apply to distilled spirits imported for other than (1) beverage purposes or (2) use in the manufacture or production of any article used or intended for use as a beverage."

The question is: To what extent, if any, does the latter act repeal the earlier?

In answer to this question the Attorney General has given the following opinion:

1. Distilled spirits produced before the passage of the war-revenue act may not be imported for beverage purposes.

2. Distilled spirits produced before the passage of the

war-revenue act may not be imported for any purpose.

3. Distilled spirits produced after the passage of the war-revenue act may be imported for other than beverage purposes and under such rules, regulations and bonds as the Secretary of the Treasury may prescribe.

4. Distilled spirits produced in the West Indian Islands recently acquired from Denmark, if produced from products the growth of the islands and produced after the passage of the war-revenue act, may be imported for any purpose, but if produced before the passage of the war-revenue act their importation for any purpose is prohibited.

Suggestions for Conservation of Coal

Owing to the difficulty of securing customary supplies of coal it becomes necessary to run existing steam power plant with the greatest possible economy. Owners and managers are urged to investigate their power costs and increase efficiency where possible. The Committee on Coal Conservation of the Chamber of Commerce of the United States makes the following suggestions:

Reconsider the advantage of buying heat and power from a specialized plant. In some localities hydroelectric power may be available.

Find the nearest source of coal that will meet the requirements, as this will relieve the tax on our transportation system.

Give to the power plant and its personnel the recognition and encouragement due to an expert and important department. Seek to increase skill and proficiency in the men who handle the coal.

Put the fuel-using equipment into as perfect condition as possible; eliminate leaks in the boiler setting and see that the firedoors fit well. Install simple means by which the fireroom force may see improved results.

Run boilers at capacity, use water free from scale-forming substances, and reduce loss of heat after it is generated by insulating boiler and pipe surfaces.

One pound of coal per hour has yielded a horsepower per hour. That is the record of present possibility. It cannot by any manner of means be attained by every plant. But the fact that at present the average attainment throughout the country is but one-third or one-fourth of this record is indicative of the possible savings that can be made if the care and attention which the power plant deserves are actually given to it.

A Correction

In our issue for Dec. 1, 1917, page 631, Mr. M. Luckiesh contributed an article on "The Physical Basis of Color Technology." Through an inadvertence he did not receive galley proof for correction, and as a consequence the mathematical equations contained a number of errors. We reproduce the equations herewith in correct form to supersede those appearing on page 636 of the issue mentioned:

$$(1)\quad J = J_0 e^{-kd}$$

$$(2)\quad \text{Log}\frac{J}{J_0} = \log T_\lambda = -k_\lambda d \log e = -\varepsilon_\lambda d$$

$$(3)\quad J = J_0 A_\lambda^{cd} \text{ or } T_\lambda = A_\lambda^{cd} \text{ or } \log T_\lambda = cd \log A_\lambda$$

Similar reference characters appearing in the accompanying text should be corrected accordingly.

Council of National Defense Reorganized

On account of the fact that the food control bill provides that corporations whose officials serve on advisory committees are not allowed to enter into contracts with the Government, the Council of National Defense has completed plans for reorganization. Under the new plan prominent industrial men will sever their connections with their industries and go into Government employ, and separate committees will be appointed by the industries themselves. The following statement was issued Dec. 7 by the Council of National Defense.

"The Council of National Defense was established to bring about the co-ordination of industries and resources for the national security and welfare. Previous to the entrance of this country into the war steps were taken by the Council so to mobilize the industries of the country that they could render effective assistance to the nation in its hour of need. The crisis made imperative the necessity for prompt action. Many industries had not been organized in time of peace so as effectively to aid the country in time of war. For these industries to organize themselves, lacking a clear understanding of what the Government would need from them in the emergency, involved delay. Since instant steps were necessary, the Council of National Defense authorized the formation, under its direction, of co-operative committees of industry to be composed of men representative of their respective lines. No other machinery existed or could have been created at that time for the accomplishment of the vital tasks at hand, which primarily were to carry the country through the transition period from peace to war.

"These committees have given faithful, patriotic and invaluable assistance to their country. Many of the individuals serving on them have done so only at great personal and financial sacrifice. The thanks of the entire country is due to these men who unhesitatingly and unselfishly responded to the Government's appeal for aid.

"Technically, however, this necessary emergency machinery set up by the Council was not in the administrative sense ideal as a means for making permanent the mobilization of industry in a democracy at war. Practically it was effective, but the committees were placed before the public in a position unfair both to themselves and to the Government. The Council and its War Industries Board, after giving this matter serious thought for some weeks, have concluded that it is now possible to arrange for meeting the Government's needs through the appointment of highly qualified individuals as Government employees and expert advisers, and also to meet the needs of industry as well as to assist the Government by representative committees created not by the Government but by the industries themselves.

"It therefore has become feasible to discontinue the embarrassing situation wherein the members of the present committes are apparently called upon to act both as Government agents or advisers and at the same time as representatives of the industries. In dissolving the present co-operative committees of industry, which were appointed by and under the direction of the Council, the action is taken only with the highest praise and thanks for their splendid and indispensable work and at the same time with the hope that representative committees of the industry will be formed by the industries themselves at the earliest possible moment. The establishment of such committees, formed so as to entitle them to speak for their entire industries, will render immediately available valuable sources of information upon which the Government can draw in connection with the countless business and industrial problems attendant upon the conduct of the work necessary for the prosecution of the war.

Bernard M. Baruch will remain as commissioner of the raw materials section, which will be divided as follows:

Explosives, chemicals, etc.—L. L. Summers, L. L. Summers & Co., New York.

Nonferrous metals and cement—Eugene Meyer, Jr., New York.

Steel—J. L. Replogle, American Vanadium Company, New York.

Oil—J. F. Guffey, the Philadelphia Company, Pittsburgh.

Bureau of Standards Urges Use of Waste Pottery Bisque

From a circular letter sent by the Pittsburgh Laboratory to makers of glass pots, and others, we give the following extract:

"In work conducted at the Pittsburgh laboratory it has been found that the waste bisque of whiteware potteries is well adapted for use as 'grog' for pots used in the melting of optical glass so urgently needed at the present time for range-finders, gun sights, periscope lenses, etc. The low content of iron oxide in this material and its homogeneous structure render it superior to the crushed pot shell or calcined clay for this specific purpose. A much smaller and limited amount of porcelain bisque may also be used, but it is very important to keep the different kinds of body sharply separated, since porcelain tableware bisque is distinct from floor tile, electrical and sanitary porcelain. The porcelain can be used only in small quantities as a fluxing constituent, while the typical whiteware body is of a refractory nature. It is evident that glazed pottery waste cannot be used, and that we are speaking here of unglazed material. It is estimated that close to 250 tons of whiteware bisque are available per month at the present time, and at a very reasonable price. Appeals to a number of large pottery manufacturers have been answered with most gratifying promptness, which speaks well for their zeal for the common good.

"The whiteware bisque is well suited also for use in the regular glass-pot mixtures, but preference should be given to pots used in the melting of optical or signal glass. The whiteware bisque most suitable for this purpose should have a softening point corresponding to Orton cone No. 30 or above.

"In being employed for this purpose, the bisque is crushed in a jaw crusher or dry pan, screened, and then passed over a magnetic separator for the elimination of metallic iron.

"The Pittsburgh laboratory is ready to give advice concerning the supply and use of this waste material to any one interested, and is ready to make softening point determinations free of charge. Inquiries should be addressed to the Bureau of Standards, Fortieth and Butler Streets, Pittsburgh, Pa."

Industrial Service Section of the Council of National Defense

The Council of National Defense has issued the following statement:

As the demands of the Government for more supplies of all sorts have increased there have necessarily arisen in the various departments placing war orders a considerable number of problems relative to proper adjustment of labor supply to the war needs.

In order to secure a basis of facts on which to work out policies, the Council of National Defense has authorized the director to undertake the following work:

1. To determine present and probable future demands for labor in war industries.

2. To determine in connection with the priorities committee of the War Industries Board the relative priorities of the labor demand.

3. To arrange for the supplying of the demand through the Department of Labor or such other governmental or civilian agencies as can best meet the demand.

4. To determine the needs for dilution of labor, including the introduction of women into industry and recommend policies to be followed in regard thereto.

This work under the council has been put under the immediate charge of Mr. L. C. Marshall, who is designated chief of the section on industrial service. Mr. Marshall comes to this work from the deanship of the School of Commerce and Administration of the University of Chicago. He has given his time recently to the special consideration of labor matters as affecting certain procurement divisions of the War Department, and thus takes up the new work with broad general information and special detailed knowledge of a number of the more pressing problems.

It is not contemplated that there will be created under the council any agencies for executive action with respect to the problems concerned. The purpose is to have under the council a section to which these various labor problems may be brought for common consideration.

The new section will work in close co-operation with the War Industries Board and its priorities committee and will, like the War Industries Board, bring to the council digested information from all Government departments as to the above subjects. Policies can then be worked out to secure the most efficient utilization of existing agencies and to facilitate the development of such new agencies as may be necessary.

Woman's Committee for Engineer Soldiers

An organization known as the Woman's Committee for Engineer Soldiers has been formed in Washington, D. C., with Mrs. Wm. M. Black, wife of General Black, Chief of Engineers, as president, Mrs. Charles Keller vice-president and chairman, Mrs. W. W. Harts secretary, and Mrs. Ulysses Grant, 3d, treasurer.

The object of the Woman's Committee is to see that no engineer soldier leaves this country without the proper knitted garments and to send garments to those already "over there." The National Committee in Washington is to be headquarters for units all over the country, and by purchasing yarn in large wholesale quantities should be able to get better prices and deliveries.

An earnest appeal is made to every man and woman interested in the engineers of the Regular Army, National Army, the Railroad, Forestry, Camouflage, or Labor regiments, to join this organization or to send contributions of money for wool, or finished knitted garments, to supply these hundred thousand men. Dues for membership, amounting to one dollar per year, may be sent to Mrs. Wm. M. Black, 1730 I Street, N. W., or Mrs. Ulysses Grant, 3d, 2204 R Street, N. W., Washington, D. C.

The Allied Purchasing Commission is now located in the new and temporary structure housing the Council of National Defense at Eighteenth and D Streets, Washington, D. C. Manufacturers who are producing or who believe their plants are in a position to produce supplies needed by the Allied Governments should make known this fact to the Allied Purchasing Commission.

Zinc Furnace Temperatures—II

Temperatures of Regenerative Furnaces

BY EDWARD MACKAY JOHNSON
Superintendent Eagle-Picher Lead Co.

CONTINUING the data on furnace temperatures given in METALLURGICAL AND CHEMICAL ENGINEERING Sept. 15, 1917, page 300, I present the accompanying curves plotted from temperatures taken on the furnaces in the checker work during periods of reversing, the first reading being taken just before reversing.

Bristol couples were used. In each case they were inserted the same distance into the checker work ports and luted up with clay. Four couples were used at the same time, with leads to one switch common to all. By this means it was possible to take four readings almost simultaneously. The following explanation of the curve numbers holds good for all curves.

If on long valve, E. or W. side:

No. 1. Top outside checker, gas entering laboratory.
No. 2. Top inside checker, air entering laboratory.
No. 3. Bottom outside checker, gas entering checkerwork.
No. 4. Bottom inside checker, air entering checkerwork.
No. 5. Top outside checker, gases of combustion leaving laboratory of furnace.
No. 6. Top inside checker, gases of combustion leaving laboratory of furnace.
No. 7. Bottom outside checker, gases of combustion leaving checkerwork of furnace.
No. 8. Bottom inside checker, gases of combustion leaving checkerwork of furnace.

Example A: Chart G, furnace No. 4, long valve, east side: Curve No. 1 represents the gas entering the top of the outside checker, and during a period of 20 minutes shows a drop of 65 deg. C. Now upon reversing, No. 5 curve represents this particular spot and shows an increase of 75 deg. C. due to the effect of the hot gases of combustion leaving the furnace.

Example B: Referring to the same chart, consider curve No. 2. This curve represents the air entering the top inside checker and during a period of 20 minutes shows a drop of 105 deg. C. Now upon reversing,

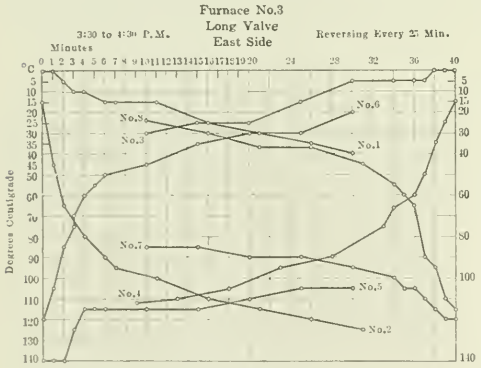
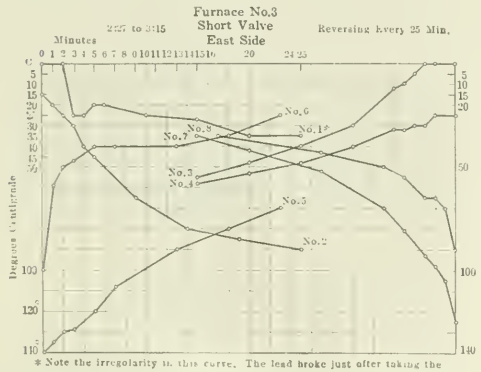


CHART A



* Note the irregularity in this curve. The lead broke just after taking the reading for this curve.

CHART C

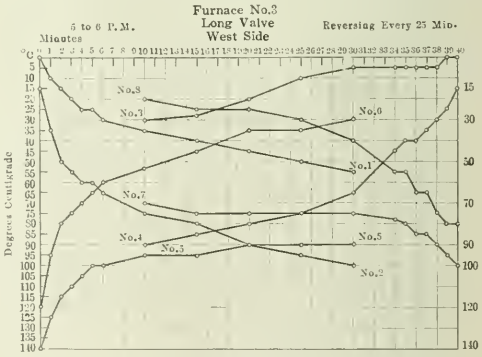


CHART B

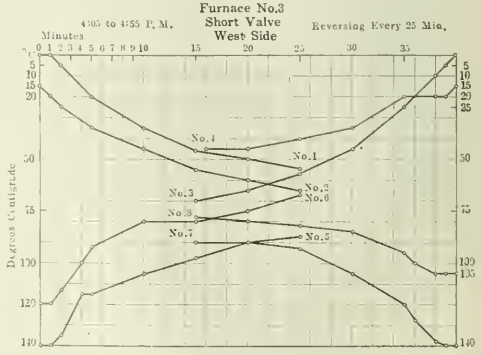


CHART D

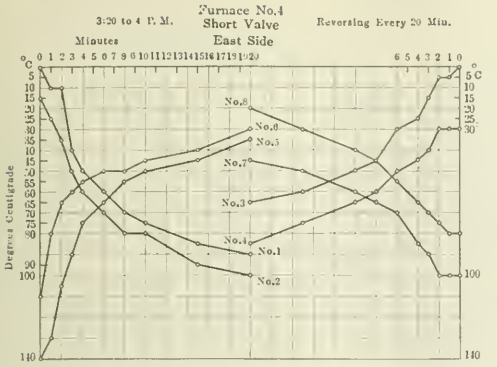


CHART E

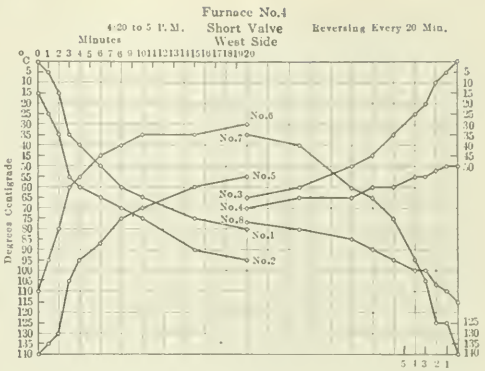


CHART F

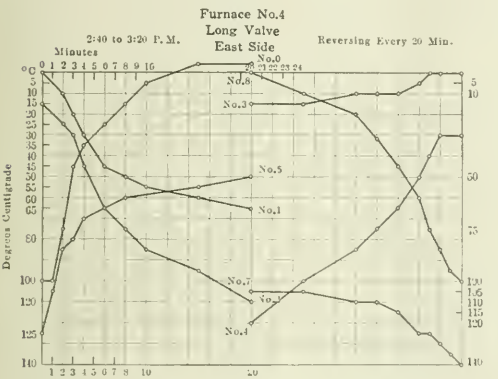


CHART G

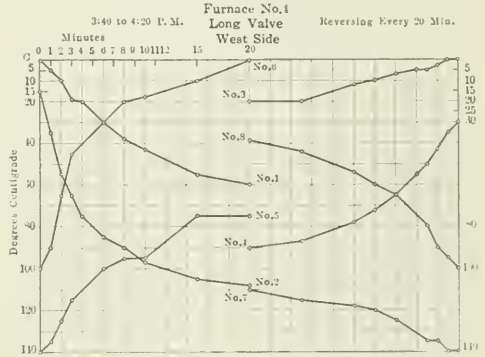


CHART H

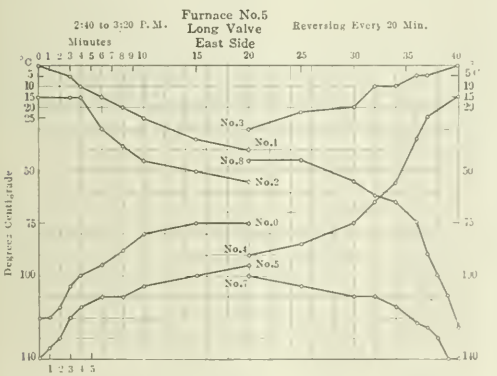
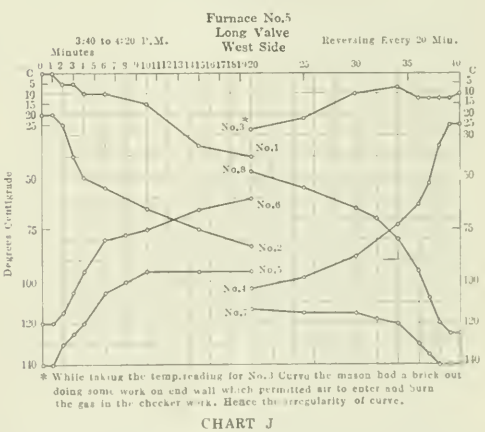


CHART I



* While taking the temp. reading for No. 1 Curve the mason had a brick out doing some work on end wall which permitted air to enter and burn the gas in the checker work. Hence the irregularity of curve.

CHART J

No. 6 curve represents this particular spot and shows an increase of 105 deg. C. due to the effect of the hot gases of combustion leaving the furnace.

In the same way comparisons may be drawn between curves 3 and 7, and 4 and 8.

Various other comparisons may be made from the curves: As between the long and short valve or between east side and west side, also between inside and outside checkers, from all of which conclusions may be drawn relative to the construction of the checker-work walls, or the height of the checker, or the periods of reversing.

Temperature of Gases Entering Stack

Temperatures taken in the four channels between the valve boxes and the furnace showing a comparison of results during a period of reversals of the gas or air entering on the east side and leaving on the west side, and vice versa, are given in the accompanying tables.

In taking the readings four Bristol pyrometers in-

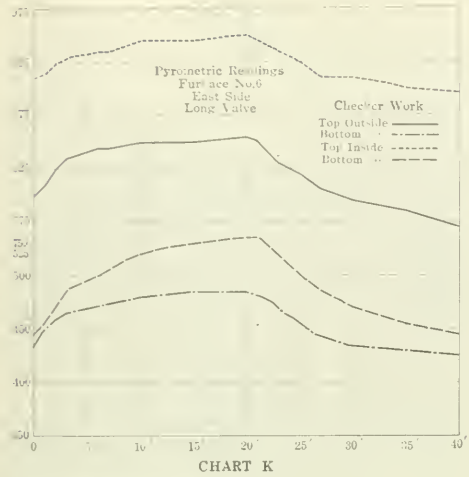


CHART K

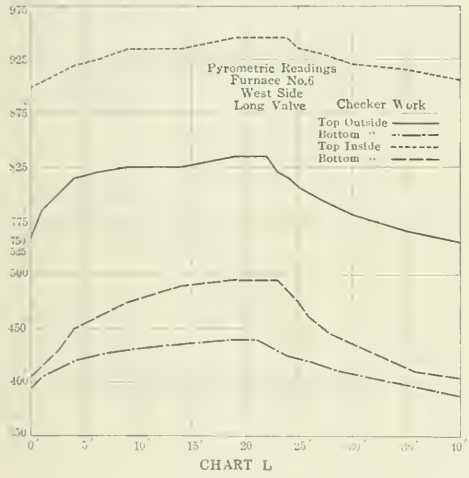


CHART L

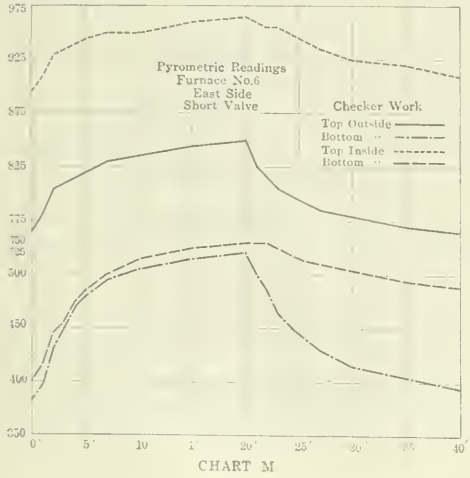


CHART M

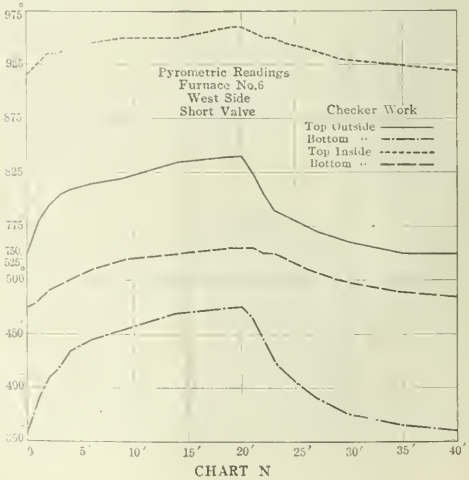


CHART N

TABLE I—STACK TEMPERATURE

Furnace No. 6—Short valve; pyrometer enclosed.

EAST SIDE			WEST SIDE		
Time	Temp. ° C.		Time	Temp. ° C.	
1:42	415	Reversed ½ hour damper.	2:01	375	
			02	370	
43	405		04	375	
44	395		05	385	
45	380		06	390	
46	375	Dumped coal in producer.	07	395	
			08	395	
47	375		09	400	
48	370		10	400	
49	365		12	405	
50	365		14	410	Dumped.
51	365		15	410	
52	365		17	415	
53	365		19	415	
54	365		20	415	Reversed.
55	370				
56	370			397	
57	370				
58	370		2:43	370	
59	370	Dumped.	44	375	
2:00	375	Reversed.	45	380	Dumped.
			46	385	
	375		47	390	
			48	395	
2:21	410		50	395	
22	400		55	400	
23½	385		3:00	405	Reversed.
24	375				
25	372			388	
26	370				
27	365		3:22	370	
28	365	Poked producer.	23	370	
30	365		24	375	
32	365		25	380	
35	365		26	385	
38	365		28	390	
40	365	Reversed.	30	395	
			35	402	
	375		40	410	Reversed.
				386	
3:01	405				
02	395		General average, 390.		
03	380				
04	370				
05	365				
08	360				
13	358	Dumped.			
20	370	Reversed			
	375				

General average, 375.

closed in iron pipes were used, connected to a switch common to all, except in the case of the stack temperatures on long valve, when the naked pyrometer was used, and, as shown by the results, gave somewhat higher temperatures than the enclosed couple as obtained on the short valve.

TABLE II—STACK TEMPERATURE

Furnace No. 6—Long valve; pyrometer naked.

EAST SIDE			WEST SIDE		
Time	Temp. ° C.		Time	Temp. ° C.	
2:24	420		2:39½	410	
25	410		41	420	
26	405		42	435	
27	410		43	445	Dumped.
28	415		44	450	
29	420	Dumped.	45	450	
30	415		46	455	
31	415		48	450	
33	415		50	450	
35	415		52	450	
38	420		53	455	
39	425	Reversed.	55	455	
			57	460	
	415		3:00	460	Reversed.
				445	
3:01½	420				
01	410	Poked producer.			
01½	400		3:20½	410	
02	395		21	415	
02½	390		22	420	
04	392		23	430	
05	395		24	435	
05½	400		26	440	
07	410		28	450	
08	415		30	455	
10	415		31	462	Dumped.
12	415		34	475	
15	425	Dumped.	37	475	
15½	430		39½	475	Reversed.
16	430			445	
17	425				
18	425				
19	425				
20	425	Reversed.			
	413				
3:40½	435				
40½	425				
41	420				
41½	410				
43	410				
44	415				
45	420				
46	425				
50	425				
53	425				
55	430				
57	435				
58	440				
4:00	440				
	425				

General average, 396.

General average, 417.

TABLE III—STACK TEMPERATURES

Furnace No. 6—Short valve. Temperatures ° C. taken in channels between the outside end wall of furnace and damper boxes.

	WEST SIDE			
	EE	EW	WE	WW
3:41	160	345	435	385
43	230	415	405	310
45	355	450	375	245
50	450	470	335	170
55	470	480	320	140
4:00	470	475	320	130
	322	439	365	230

General average, 339°.

	EAST SIDE			
4:01	450	410	330	170
03	380	385	360	270
05	300	350	395	360
10	215	330	440	430
15	175	325	455	450
20	160	320	465	455
	280	358	107	356

General average, 350°.

California yields commercially a greater number and variety of mineral products than any other State and probably more than any other equal area of the earth. Previous to 1916 the total annual value of her output was surpassed by but four other States, they being coal and iron producers east of the Mississippi.

Recent Development of the Côte and Pierron Electric Zinc-Smelting Process

INTERESTING and hitherto unpublished details regarding the most recent step in the evolution of the Côte and Pierron process have just been published by G. Flusin in the *Bulletin Technique de la Suisse Romande* of Nov. 17, 1917 (vol. 43, No. 23, p. 233).

A plant is actually in course of construction at Maurienne, near Epierre; it will be put into operation at the close of this year and its equipment will comprise four furnaces of 500 hp. each. The working capacity of each furnace will amount to four metric tons of zinc ore per 24 hours.

The essential features of the present modification of the C. and P. process are as follows:

1. Treatment of raw ores, without previous roasting (ordinary blendes, fluorspar-containing blendes, mixed ores containing blende and galena).

2. Use of lime and carbon as the only raw materials for the preparation of the fusion bath.

3. Use of a "compound" furnace formed by the cooperation of two adjacent furnaces, viz., one being an "arc-resistance" furnace and the other an "indirect-resistance" furnace, combined in such a manner as to constitute practically only one continuously operated unit. Smelting of the charges is effected roughly to some extent, in the first furnace with liberation of zinc in the form of vapor. The second furnace, which acts as a refiner, receives the crude metal in form of droplets and zinc dust and, without allowing it to cool down, and with an additional small supply of calories, separates it from all the entrained impurities by subjecting it to a second process of distillation, followed by condensation in the fluid condition.

As will be seen, the process consists of effecting fusion of zinc ore in an electric furnace in order to liberate the crude metal therefrom and of refining this metal at once, likewise in an electric furnace, as fast as it is produced while its temperature is still near that of volatilization.

It will be observed that the inventors have given up the method of smelting zinc sulphide ores with iron as desulphurizer and that they have reverted to the smelting of the raw ores in the presence of lime and carbon. On the other hand, they have been successful in avoiding the deleterious effect of CO and other gases and in doing away with intermediate formation of zinc dust.

The ores best suited for this process may have a range of composition as follows: Zn, 30-40 per cent; Pb, 5-15 per cent (incl. Ag.); Fe (as oxide or sulphide), 8-12 per cent; S, 20-30 per cent; CaO, SiO_2 or BaO, 10-15 per cent; Fl, 3-5 per cent; foreign metals, 2-3 per cent; As, 2-3 per cent (tolerated).

The Epierre type of furnace (500 hp.) is capable of smelting 4000-4500 kg. of ore per 24 hours, which corresponds to a current consumption of 2000-2200 kw.-hr. per metric ton of an ore analyzing 35 per cent zinc as the average. Only 1.5 per cent zinc remains in the slag. The metal as it comes from the condenser titrates at once 99.93 per cent zinc. The total losses amount to 8-9 per cent (sometimes only 6-7 per cent). The electrode consumption amounts to 12 kg. per metric ton of ore. The 500 hp. above referred to is distributed as follows: 350-375 absorbed by reactions in the fusion bath, and 150-125 in the condenser.

A Furnace for Testing Refractory Materials Under Load at High Temperatures

By Robert J. Montgomery

Contributed by the Laboratories of the H. Koppers Company and the Pittsburgh By-Product Coke Company

THE furnace described in this paper has been used for two years with complete satisfaction, and it was thought that the design might be of interest to laboratories testing refractory materials.

The accompanying sketch Fig. 1 gives the design in detail. The furnace chamber is circular and may be built of wedge brick, leaving vent holes at various points to allow the inspection of the test pieces. The chamber is heated by two burners using gas and compressed air. These are placed at the level *C* and on a tangent to the chamber. This type of burner gives a whirling action to the flame and a very even heat distribution. The gases escape through the 4-inch circular flue *D* in the center of the bottom between the test brick, which leads to the stack. In order to make sure that the furnace is full of gas and to help in the regulation of the mixture of air and gas, small vent or inspection holes are left open near the top, one above each burner, at the level *E*.

The method of setting the test brick is best shown in Section *AAAAAA*. The brick are set on end on a refractory block *FF*. On the brick are placed the cups *GG*. Then the refractory rods *HH*, which extend through the top of the furnace. This cup and rod arrangement was found to be necessary when tests were made under very severe conditions, such as a 100-pound per square inch load at 1500 deg. C., and it will be found that if the refractories of which the furnace is built are of the same quality as the material tested the furnace will work satisfactorily. The cup takes the highest temperature of the furnace and will not last through many tests, but protects the rod, which will last very well. The cross-sectional area of the rod should be about one and one-half times that of the test piece to stand the strain of severe conditions. The design might be changed somewhat when special refractories are available.

Returning to Section *BB*. On the refractory rod is placed an iron cap *I*, containing a steel knife edge, which engages the grooved plate *J* on the beam *K*. This beam is pivoted at *L* and is balanced by the counter weight *M*. The height of the beam is adjusted by the spindle *N* and hand-wheel *O*. The beam is kept true by the vertical guides *P*. These guides are drilled every inch for a pin support for the beam when the furnace is not in use. The beam acts as a lever in the proportions of one to four, the load being placed on the hook at the

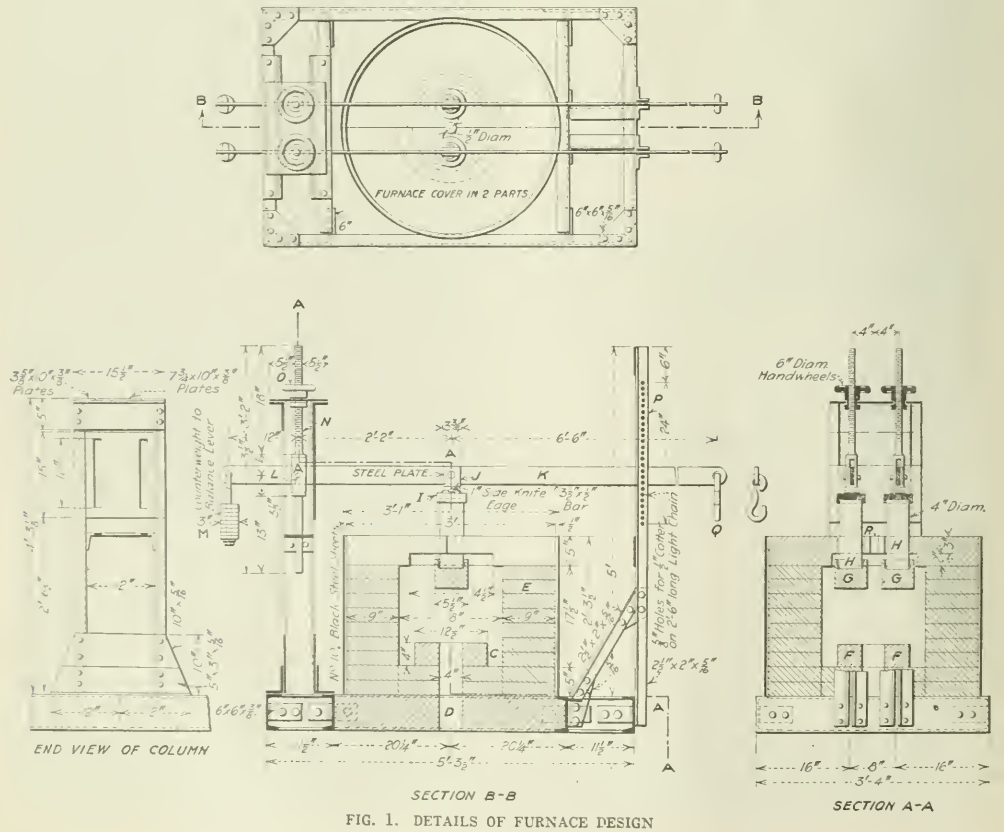


FIG. 1. DETAILS OF FURNACE DESIGN

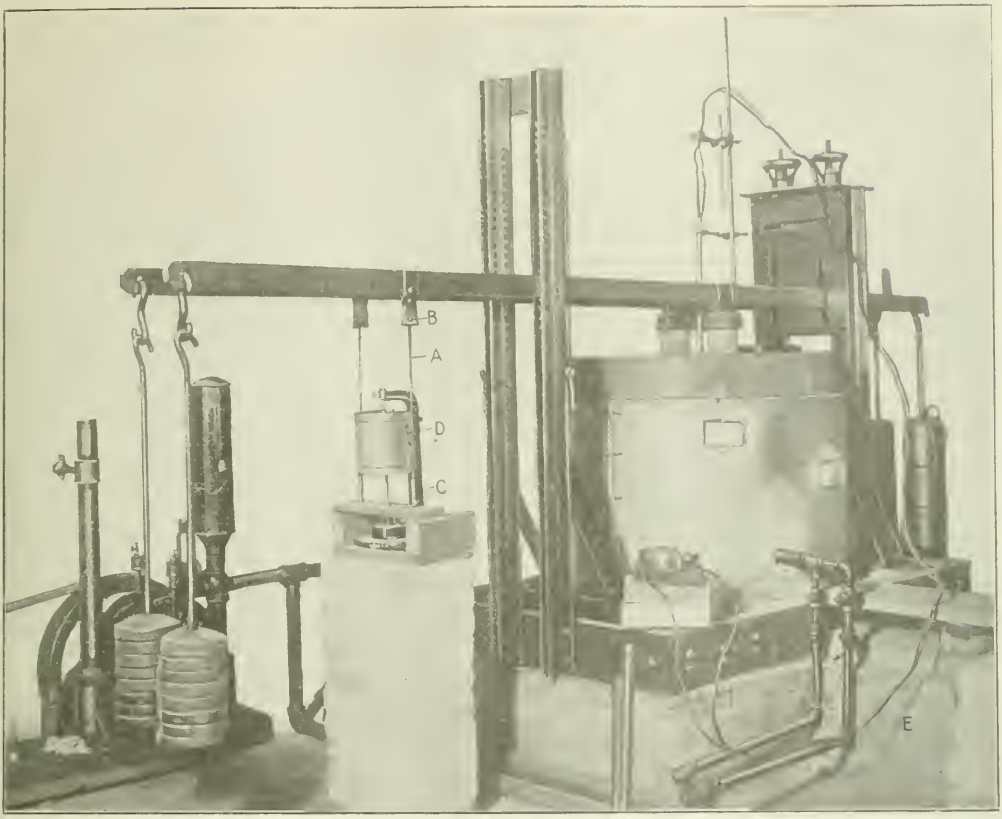


FIG. 2. FURNACE FOR TESTING REFRACTORY MATERIAL

end of the beam. A beam $\frac{3}{4}$ in. by $3\frac{1}{2}$ in. will take a load of 25 to 35 lb. per square inch on a standard sized fire brick without undue deflection and one $\frac{3}{4}$ in. by $3\frac{1}{2}$ in. will take a load of 75 to 100 lb. per square inch.

The beam is leveled at the beginning of the test, and it is not necessary to readjust after starting. The distance between the pivot and the knife edge is great enough not to cause any noticeable eccentric loading. With as high as 15 per cent shrinkage on the test brick the bar is not very far below the original level. By not adjusting the beam a drum recorder may be used to make a complete record of the test. A pyrometer with a three-foot element is inserted through the hole *R* in the cover and extends to the center of the combustion chamber. The cold junction of the couple is protected by an asbestos guard and a correction is made in the readings by adding one-half of the cold junction temperature to the galvanometer reading. The photograph Fig. 2 shows the furnace, with a blower for the air supply in the background. The vent or inspection holes may be seen in the sides of the furnace. The recording device is shown, which gives a movement of three times that of the test brick. The brass rod *A* is pivoted at *B* so as not to bind in the brass guides *C*. A pen *D* is mounted on the rod *A* and it engages the drum recorder. A horizontal flue *E* runs under the furnace to the stack.

Fig. 3 shows sketches of the special shapes required.

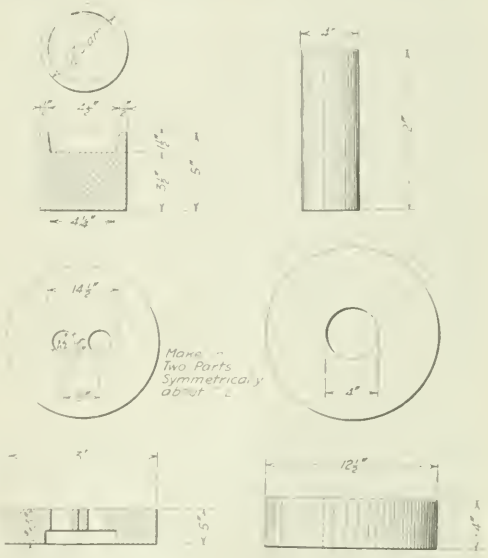


FIG. 3. SPECIAL SHAPES REQUIRED FOR FURNACE

The cover *A* is split through the center to allow the easy adjustment and placing of the test pieces and pyrometer. The ring *B* corresponds to *F* in Fig. 1. As this ring cracks quite easily in operation it could be replaced by two highly refractory brick or special refractory block as the base for the test piece.

The main points in this design are:

1. Two bricks may be tested at the same time, resulting in considerable economy.

2. A down-draft feature which increases the uniformity of the temperature throughout the combustion chamber.

3. The circular combustion chamber and tangential burners give better heat distribution than burners placed at right angles to the furnace.

4. A proper proportioning of the refractory cup and rods allowing maximum temperature and load to be used for the refractory tested.

5. A simple means of applying the load and of obtaining a continuous record of the test.

Disadvantages of Chrome Brick in Copper Reverberatory Furnaces

IN a paper to be presented at the meeting of the American Institute of Mining Engineers in New York, in February, 1918, Mr. FRANCIS R. PYNE offers the following notes on the disadvantages of chrome brick in reverberatory furnaces handling material too valuable to allow of much absorption by the brick.

Several years ago one of the large Eastern copper refineries decided to utilize basic material in place of siliceous material in the walls of their reverberatory furnaces for the treatment of very foul blister copper, as the latter rapidly corroded the siliceous linings.

Magnesite brick were first used, but while the corrosive action of the foul material was greatly reduced, and the amount of slag formed was very much less, the magnesite proved to be unsatisfactory in certain parts of the furnace, because of its tendency to crack and spall badly when subjected to the alternate heating and cooling that takes place in a reverberatory refining furnace. It was therefore decided to substitute chrome brick for magnesite brick in the parts of the furnace affected. The results, as far as the reverberatory furnace was concerned, were very satisfactory. The corrosion due to the action of the foul blister was small and the amount of slag formed was no greater than when using magnesite, and the tendency to crack and spall shown by the magnesite was eliminated. Gradually the use of chrome brick was extended to all furnaces, those treating blister copper as well as those melting cathodes, and the results were so satisfactory that the siliceous roofs were replaced by roofs of chrome brick except in certain places where experience showed a more satisfactory performance on the part of the silica brick.

It was immediately recognized, both for the magnesite and chrome brick, that the metal absorption was very heavy, but it was felt that the longer life of the furnaces and the decreased cost of slag treatment and metal losses would more than offset this disadvantage.

When repairs had to be made to the furnaces, the resulting cobbing was sent to the blast furnaces for the recovery of the copper, silver and gold contents. It was, of course, realized that chrome was a neutral material and could not be fluxed, but it was thought that, at the blast furnace temperature, the cobbing would be melted, releasing the locked-up values and causing the chromium oxide to pass out mixed with the blast-furnace slag.

For a time this method appeared to be satisfactory, but as more of the cobbing was made and treated in the blast furnaces, trouble developed. The capacity of the settlers began to be seriously reduced and slag losses increased, due to improper settling. On investigation, it was found that there had formed in the settler, between the matte and the regular slag, a layer of thick, mushy slag which was causing the trouble.

This mushy slag could not be fluxed, could not be tapped out with the matte, and would not of itself overflow through the slag spout. The only way it could be removed from the settler, without shutting down and digging it out, was to insert a pipe into the layer and by the use of compressed air cause it to mix and overflow with the regular slag. While this procedure cleaned out the settler, it also resulted in metal losses that could not be tolerated. Samples of this mushy slag showed it to contain as high as 25 per cent chromium oxide, indicating that the cause was in the chrome cobbing added to the charge. Upon discontinuing the treatment of the cobbing, the settler trouble disappeared. The natural result of this was to accumulate a considerable stock of the chrome cobbing, and experiments were undertaken to devise a satisfactory process for the removal of the values that would leave a residue that could be sent to the dump.

The cobbing was crushed fine, thereby releasing the larger metallic particles, and treated in a reverberatory furnace with roasted pyritic ore and silica. This treatment gave a fairly fluid slag in which the chromium was apparently soluble. A considerable amount of the metal values was thus recovered, but the slag was still too rich in copper to throw away, and when sent to the blast furnaces induced a return of the former settler troubles.

Fine crushing and fusion with a very low-grade matte was expected to remove the values and leave a slag sufficiently low in copper to be discarded. The results were unsatisfactory, for though the matte absorbed much of the values, yet the slag was thick and pasty and contained considerable copper.

It was felt that crushing followed by mechanical concentration might result in separating the metal from the brick. Accordingly, the material was crushed and screened to remove the coarse metallics and was then treated on a Wilfley table. There was sizing, but little concentration.

Flotation was also tried without success, as the concentrate was too rich in chromium and there were too many values in the residue.

The most satisfactory solution yet found for the disposal of this material is to grind it, thereby freeing the larger metallic particles, and utilize the fine material in the manufacture of refractory brick, thus using the cobbing over and over again. There is, of course, some slagging action and a certain amount of chromium goes to the blast furnace where the mushy slag is formed, but in small amounts it is easily taken care of, and eventually the accumulated stock will be "worn out" and sent to the dump. There are also possibilities of treating this material by converting it into ferrochrome or by making chromate salts.

Our Resources

Address Delivered at the Tenth Annual Meeting of the American Institute of Chemical Engineers, St. Louis

BY G. W. THOMPSON
President, American Institute of Chemical Engineers

WHEN we speak of resources we usually have in mind material things, such as financial, mineral and agricultural resources. It would appear, however, that this is a rather limited construction of the meaning of the word "resources," for with all of these material resources there is the presupposition that one has the ability to use them. Wealth owned by an idiot may not be to him a resource, but rather a liability. A mining deposit that no one knows how to work is hardly worth calling a resource. Wonderfully fertile fields in the centre of Africa are not resources, to the extent that they are removed from the intelligent use of civilized men. In our own country it is true that wealth, mineral deposits, and fertile fields are resources, but they are such because there are resourceful men in our country who can use them. If the present war teaches us anything, it is this: In these days wars cannot be won because a nation has great material resources only, but rather because a nation has resourceful men.

Let us consider this carefully and see whether what I have said is true and what, if it is true, it implies. Mexico is a country that is wonderfully rich in possibilities. Unfortunately for Mexico, whatever the cause may be, the Mexicans have not, themselves, so far developed their possible resources to their country's full advantage. In so far as these resources have been well developed, it has been because resourceful men have gone to Mexico and endeavored to turn mineral and agricultural resources to profitable ends.

The mechanical ability of the citizens of the United States has been recognized all over the world. Give him a mechanical problem, and it is not long before that problem is solved. His agricultural machinery, his machines for the manufacturing of food products, his machines for the stamping and molding of metal, his machines for the utilization of electrical energy, and hundreds of other kinds of machines are evidences of the great mechanical resourcefulness of our citizens.

It should be borne in mind, however, that the mechanical engineer's peculiar field lies in the taking of materials and turning them into machines. The materials must be furnished to him. On whom then does this furnishing of materials to the mechanical engineer mostly depend? I think it will be admitted that the furnishing of materials depends mostly upon the chemist. All of our smelting operations are highly developed chemical manufacturing processes. After metals have been won they must be combined together and with non-metallic elements, in order that they shall be serviceable to the mechanical engineer. Agriculture is a chemical process, and agricultural products must be treated or prepared chemically before they can be used to the best advantage. It may be that it is not as generally recognized as it should be that all smelting and agricultural operations are chemical operations; nevertheless we as chemists perceive this truth as a reality.

We see, therefore, that machines cannot be made unless the materials needed for them have been provided, and we see also that the production of raw and semi-raw materials depends, to a great extent, upon the resourcefulness of the chemist. Whatever the material resources of a country may be, these resources cannot be made fully effective unless efficient chemical processes for their utilization have been worked out.

I must say a few words here, lest I be misunderstood and be thought to be claiming too much for the chemist. In the development of a process for the production of the chemical elements or compounds, the chemist is essential. To make these products on a commercial scale, the mechanical engineer or his equivalent is also necessary. By the equivalent of the mechanical engineer we mean the person who knows how to apply material forces to machines and appliances so as to obtain effective results, and one also who knows how to construct these machines. The person who knows chemistry and chemical processes adequately and who also has a broad knowledge of the field of mechanical engineering, constitutes that modern product of which each of the members of our Institute is a representative—the chemical engineer.

Analysis and synthesis, to a certain extent, parallel each other. In analysis we seek to know the ultimate composition of substances; that is, the elements they contain. Having this information, we then seek to know how these elements are chemically combined; i. e., the constitution of the chemical compounds present. There are, therefore, two limits which confront the analyst. In making an ultimate analysis he cannot go beyond the elements themselves. He cannot decompose them into other constituents. The time may come when he will be able to do this, but the prospects are that that time is a long way off. The other limit lies in his determination of the constitution of chemical compounds. This is not a fixed limit, and the information we are obtaining every day is shoving this limit further back and widening the chemist's horizon. So, too, with the synthesist. He has the same fixed limit as the analyst. He cannot combine substances to produce elements, and he has a similarly continually widening limit as to the compounds that he can synthesize. He is adding continually to the superstructure which rests upon analysis.

Methods of Developing Material Resources

The materials which a country needs may be obtained from its material resources in four ways, in all of which ways the chemist is preëminently the active factor.

First: By the production of commercially pure elements from minerals, such production being by methods which may with propriety be called analytical. In this way lead, silver, copper, etc., are obtained.

Second: By the production of such chemical compounds as are found in mineral deposits or in plant

and animal bodies. These compounds are isolated by methods that are also essentially analytical. In this way common salt, cane sugar, glycerine, etc., are obtained.

Third: By the production by synthetical methods of such chemical compounds as are referred to in Class Two. In this way indigo has been produced.

Fourth: By the production by synthetical methods of compounds not produced by nature, i. e., not found in mineral deposits or in plant and animal bodies. In this way innumerable inorganic compounds such as the salts of the heavy metals, and many inorganic compounds such as the so-called coal-tar dyes, have been obtained.

It is not to be assumed that these are the only ways in which the chemist is the active factor in the production of useful materials, but the four classes of materials given serve as a basis for the systematic study of our resources.

We will attempt now to review, in as general and condensed a way as possible, some of the resources of our country and the relation of the chemist to them, what he has done, what apparently he will be unable to do, and what we may hope for him in the future.

Considering the chemical elements which are included in Class One, it is quite evident that we have a reasonably ample supply of the minerals which contain the following elements: aluminium, arsenic, barium, boron, calcium, copper, carbon, iron, lead, magnesium, phosphorus, silver, sodium, titanium, and zinc. It is true that under pre-war conditions some of these elements, or the minerals containing them, were imported, but they were all produced in this country and the amount imported was insignificant as compared with home production. Elements such as arsenic, barium, calcium, magnesium, phosphorus, and sodium were mostly used in chemical compounds. Arsenic was produced mostly as a by-product of smelting operations, in the form of white arsenic. Barium was produced mostly as mineral barium sulphate or barite. Calcium and magnesium were produced to some extent as metals but were mostly in the form of chemical compounds. Phosphorus was produced to some extent as an element but was mostly used in fertilizers as acid phosphates. Sodium was produced in large quantities in the metallic form but was mostly used in chemical compounds such as caustic soda and sodium carbonate. The modern chemist gave us methods of producing aluminium, magnesium, phosphorus and sodium. The modern chemist has developed practically all of the metallurgical processes on which the production of copper, gold, iron, lead, silver, and zinc rests. He gave us the electrolytic refining of copper, the cyanide process for the recovery of gold, the structural knowledge of steel, the Bessemer and open-hearth processes for making steel, processes for the electrolytic refining of lead, and processes for the electrolytic production of zinc. All of these contributions of the chemist have greatly increased the output of these elements and rendered them more available for useful purposes. It is obvious, of course, that we have an ample supply of such elements as chlorine, hydrogen, nitrogen, oxygen, and silicon, all of which the chemist uses in the production of chemical compounds.

For some years before the war the production of bromine was a profitable industry, in spite of the unfair competitive conditions under which it labored.

In the case of carbon, we have an ample supply, although in its allotropic forms, graphite and diamond, we have not all of the supplies that could be desired. The chemist, however, has given us an artificial graphite which, to a great extent, has supplied our needs for this material, and he has also given us abrasive compounds that approach the diamond in hardness. With regard to all of these elements, the chemist is continually contributing to their more economical production and use.

We must not neglect to mention sulphur, which, when converted to sulphuric acid, is the basis, practically, of all chemical industries. Although large quantities of pyrite have heretofore been imported, the importation of sulphur itself has fallen to a negligible amount, due to the production of sulphur by the methods developed by Frasch. It would appear also that the recovery of sulphur compounds from smelter gases would, under normal conditions, more than supply our needs, taken together with our other sources of production. At the present time the supply of sulphuric acid may be considered as inadequate, but this is due only to extraordinary demands created by the war, and it would seem probable that even those demands could be met satisfactorily at an early date.

There are some elements of which we have no appreciable supply. One conspicuous example is iodine. Practically the entire world's production of iodine comes from Chile, where iodine is obtained as a by-product of the nitrate industry. If the need were great enough, however, iodine could be obtained by the old-fashioned method—from seaweed.

Antimony has been very little produced in this country, probably due to economic reasons, although scattered deposits have been found and worked. If the need were great enough, undoubtedly antimony could be produced. We are fortunate, however, in having a large quantity of antimony in the form of antimonial lead which is obtained as a by-product of the lead smelting industry, antimonial lead being suitable for most purposes where antimony and lead together are used. If the need came, there would be little trouble for the chemist to separate the antimony from the lead.

It is rather curious that there has not been a great quantity of manganese ore produced in this country. Just why this production has lagged is rather difficult to say with certainty. Manganese deposits exist, and even if they are not of the particular grade desired, say in the steel industry, their purification by chemical means is not difficult. The cheapness of manganese ores and recovered manganese obtained from abroad before the war was probably principally responsible for our undeveloped production here. It is true that a large quantity of manganese is obtained as a by-product from zinc ores in New Jersey, but that supplies only a small part of our needs. Should the importation of manganese ores and products be rendered more difficult, it would seem that the only way that the required amount of manganese could be obtained would be by the development of our own deposits and probably the calling in of the chemical engineer to develop methods of separation and purification.

We have no platinum deposits in our own country, but there are great quantities of platinum in the country in the form of jewelry, etc., that should be available for the war needs of our country.

We have no great deposits of nickel and cobalt and it would appear that we must depend, for some time at least, upon the Canadian supplies, it being very fortunate for us that we are on such friendly relations with our Canadian brothers.

Since the war began our lack of a supply of potassium salts has been manifest, not merely to us but to Germany, the country from which our supplies mostly came. It is evident that this shortage must be met, and it can only be met by the help of the resourceful chemist. It is not due to the absence of potassium from our mineral deposits that we have not been able to supply ourselves, but it is due to the fact that before the war started, the production of potassium in this country was not developed as a commercial proposition. There are large quantities of potassium in our feldspar, in our alkaline lakes, and in various materials used for the production of Portland cement and beet sugar. There are great quantities of potassium in seaweeds. The production of potassium compounds must be developed. Our country must be supplied, and it is up to the chemists to supply it. Considerable quantities have already been supplied and larger supplies may be expected.

We have no tin deposits of great value in this country, although tin is a widely distributed element, especially in the southeastern states. There seems to be no probability that the chemist will be able to do very much in the near future in the way of giving us a supply of tin ore. He has, however, been of invaluable assistance in the development of processes for the recovery of tin from tin scrap, and it would seem as if at some time in the future, when the stress is sufficiently great, methods will be developed for the collection of much larger quantities of used tin articles and their treatment by detinning processes whereby this semi-precious metal will be recovered.

There are many other elements, more or less rare, to which I could refer. What we have endeavored to show so far is that with regard to most of the elements the chemist has been an important factor in their production, and that the chemist promises, with some few exceptions, to be a still more important factor in the future.

Importance of Synthetic Products

We now come to Class Two, which are those chemical compounds found in mineral deposits or in plant or animal bodies. It would be convenient for us, however, to consider Class Three in connection with Class Two. In Class Three we have those chemical compounds referred to in Class Two, which have been produced by synthetical methods. With very few exceptions, the inorganic compounds included in Class Two, where the need has arisen, have been synthesized and appear in Class Three. It is true that certain minerals have not been synthesized in the physical form corresponding to the mineral; thus asbestos is mined as a mineral product and there has been no demand for the production of anything similar to asbestos by a synthetic method, as the supply which mostly comes from Canada has been reasonably ample.

So too with cryolite used in the electrolytic manufacture of aluminium. It is imported almost entirely.

It is when we come to organic compounds that the significance of our classification becomes more striking, and the chemist must admit that, while great progress has been made in the knowledge of the constitution of organic compounds found in nature, the development of their commercial production synthetically has not made as great a progress as could be desired. It is true that some of the natural dye-stuffs, such as indigo, have been produced synthetically, but there still remains a very large field which is unworked. It seems probable that the lack of progress in this direction has been due to the abundance of our supplies. Our country has had ample quantities of sugar, starch, turpentine, oils, and fats, and hydrocarbons for its needs. It has been easier to produce these things by depending upon "mother nature" than it has been to work out synthetic processes. There need be no criticism of the chemist for this fact, but in the stress of war it is brought home to us how desirable it would have been if certain arts had been developed from our synthetic knowledge that would be available in our present struggle. There are certain things which we do not produce in appreciable quantities, such as shellac, rubber, and the fossil gums. Rubber has been produced synthetically, but, for some mysterious reason, when the methods were announced, the supply of rubber from natural sources became so great that the production of synthetic rubber was rendered unattractive commercially if for no other reason.

During the war the demand for glycerine has become very great. Some day a commercially profitable method for synthesizing glycerine will be developed. Perhaps we have learned our lesson so well that that day is nearer at hand than we dare hope. Let it not be supposed, however, that the chemist has not been active in these two important fields. While he has not developed, commercially, processes that actually synthesize many organic compounds of commercial value and produced by nature, the chemist has transformed many chemical substances into compounds of greater commercial value. The chemist has converted various oils into edible products. He has also, by hydrogenation, changed liquid oils to solid fats, bringing about a much closer parity in price between oils and fats of various origins. He has developed methods for more cheaply producing alcohol and acetic acid. He has produced sugars from starch. He has produced synthetic resins which, to some extent at least, have replaced shellac and the fossil gums. He has produced rubber substitutes which have at least the merit of having kept down to some extent the price of genuine rubber goods. He has developed methods for the recovery of rubber from waste products. He has converted mineral oil into satisfactory substitutes for turpentine. He has continually added to the yield of these natural and other products, by the study of the natural processes by which they are elaborated.

We must not neglect to mention the most important compounds found in nature, of which we have no natural supply. I refer to the nitrates. We have no nitrate deposits, but in that respect we are not less favored than most other nations. The nitrate supplies of the world, for a great many years, have come from one part of the west coast of South America. Germany was one of the first countries to realize its deficiency in this respect, and Germany bent its best efforts toward producing nitrates synthetically. At first her supply of synthetic nitrates was developed in Norway where great water-power resources existed. Later, to make herself

more self contained, she developed other processes, so that to-day she is practically independent of South America and Norway. Without discussing the merits of any particular process for producing nitrates, it is apparent to us that it will not be long before our country has adequate supplies. Partly, it may be by processes originally developed in this country, involving the direct combination of nitrogen with oxygen, and partly, by other processes involving first the production of ammonia and then its oxidation. It seems probable that next to sulphuric acid, nitric acid is the most important chemical needed in the development of our industries, and we should look forward to the much delayed time when nitrogen compounds will become more available.

It is in Class Four, however, that the chemist has been so conspicuously effective, for in Class Four we have those compounds which are not found in minerals or in plant or animal bodies, but are essentially artificial compounds. Here we could fill a long list, if we were permitted, of the inorganic compounds alone that the chemist has produced from every one of the elements by combining it with others. If we attempted to list the organic compounds produced, the list would probably be longer than that of the inorganic compounds. So far these purely synthetic compounds have not shown themselves to possess food values, but as decorative materials, as preservatives, and as medicinals their use has been very great. In the dye industry the artificial dyes have largely displaced natural dyes.

Considering the foregoing as a description of the four classes of materials which constitute the material resources of our country, a very proper criticism could be made that this account is very crude and inadequate. It serves, however, the purpose I have had in mind and which I have already outlined as illustrating the relation of the chemist to our resources, and it serves also as a preface to certain other very important considerations which I will now attempt to outline.

Necessity for Protecting New Arts and Industries

During the present war many processes have been developed in this country for the purpose of increasing our supply of needful materials. Many of these processes have been developed into successful commercial form. Arts have been established.

I think every one who has been instrumental in developing these arts, and many others also, have asked themselves what is to become of these arts when the war is over. Are these arts, due to foreign competition, to become extinct and lost as it were, or will they be able to stand on their own feet in face of that competition? The answers to these questions will vary according to the arts. Some have, undoubtedly, become firmly established and will withstand foreign competition. Others, undoubtedly, will tend to become lost arts, and this tendency should be considered as most unfortunate. Now is the time to study this question and prepare to meet it when the war is over; meet it if need be by allowing the arts to perish, or, if it is more desirable to maintain the arts, by appropriate methods of procedure.

Let us consider this by way of illustration. As indicated above, the production of potash in this country is not to-day equal to the demands of our country. It would seem probable that when the war is over, if Germany follows its old practice of unfair competition, the potash industry will have to cease operations. Potash can be produced in Germany and sold here probably cheaper than we can make it in the near future. A great deal of money has been expended in the development of the art of producing potash in this country. Shall we allow that art to become extinct?

Our government has prepared for the expenditure of a large sum of money for the fixation of nitrogen and the production of nitrates. It can hardly be expected that when the war is over and the demand for nitrates falls off, that immediately the processes and arts which have been developed will be able to withstand the competition of Chile. Nitrates can be produced in Chile at a figure which will probably be lower than what they will be produced for in our government plants when the war is over, unless the war lasts for a long time.

Artificial rubber has never been manufactured in this country. Chemical processes involving its production synthetically may be known. The war has created a great demand for rubber. Should the war last long enough, it might be profitable to develop the production of synthetic rubber, and after the war the art would find difficulty in living.

This prospect of any art perishing in our country is not a pleasing one to me, because it involves a loss of resourcefulness which to me is of more importance than a loss of resources.

The examples I have referred to are by no means the best examples that could be selected. Each of you can probably suggest a better example. They serve our purposes, however, and indicate our needs. They present to us a problem which deserves very careful consideration. Many solutions of the problem can be offered. Undoubtedly, in the case of nitrates, the production can be continued even at a loss after the war is over, provided sufficient pressure is brought to bear upon our legislators.

In the case of potash the problem is somewhat different. Such production is to-day in private hands, and it would appear unreasonable to expect private capital to continue for any length of time to operate a losing or unprofitable business. Undoubtedly, after the war is over more potash will be produced at a profit in this country than there was produced before the war, but the amount will be insignificant. I hold no brief for any potash manufacturer and do not know, directly or indirectly, anyone engaged in such manufacture. Therefore what I have to say is entirely disinterested. We have to-day government-controlled industries. This government control of industries is a war measure. I would hesitate to advocate any control of industries, in general, in times of peace, but wherever there is a case like the potash industry, which is very important to the life and progress of our nation, it seems to me that we have a special case involving special forms of treatment and consideration. It is not very desirable now that any branch of the potash industry be made a government-controlled industry, but when peace comes it seems desirable that some, at least, of the potash industries be put under government control, so that the arts so far developed will be maintained and further development provided for. I believe that the potash industry should be controlled and subsidized, the ex-

pense of the subsidy perhaps being met by a very small tax upon imported potash.

In the case of artificial rubber, it would seem that the rubber manufacturers could afford to organize an institute which would be profitable to all the manufacturers and be for the purpose of developing methods for the production of artificial rubber and allied products. It seems that here government assistance should not be necessary as in the case of potash. The rubber manufacturers should, if practicable, establish an art which could be controlled by patents, each of the rubber manufacturers deriving proportional benefit.

What we have suggested with reference to the nitrate, potash, and rubber industries, should be considered only as types. Perhaps there are other products in regard to which a method of treatment could be developed similar to that suggested in these three cases.

What I have endeavored to indicate in this paper is this: It is not sufficient for us to consider simply what our resources may be, but we should also consider how our resourcefulness can be developed. Undoubtedly much can be done by the education and employment of more chemists and the better education of each chemist. Much can be done by the broader and more intelligent education of chemical engineers, but there still remains the problem of maintaining such arts as have been developed during the war, and the further development of the new and old arts which are now successfully practiced. In some cases I firmly believe that the maintenance of these new arts and the development of other newer arts cannot be accomplished unless there is a broader conception of the advantages of community action based upon community interests.

Brooklyn, N. Y.

The Use of Culm and Other Waste Materials from Coal-Washing Plants for Other Purposes

BY JOHN B. C. KERSHAW

ONE unlooked-for result of the increased cost of labor and transport in all manufacturing countries is that the "dumps" of waste-fuel in colliery districts are growing in size, and that the proportion of fuel left in the mines as "unmarketable" and not worth bringing to the surface, is far greater than is desirable from the point of view of national economy.

Large consumers of fuel, in towns and cities far distant from the coal-mining areas, have in fact now recognized the absurdity of paying high freight and railway charges upon such incombustible matter as water and ash. Consequently washed and properly graded coals are rapidly growing in favor with these classes of consumer. The coal-washing and cleaning plants at the pits tend, therefore, to multiply in all up-to-date mining centers, and the dumps of culm and other washery refuse are growing in size and in economic value.

So far the attempts to utilize this waste material for steam-raising, or other power purposes, have been confined chiefly to the mining companies themselves, but with the extension of their plants the time is rapidly approaching when they will be unable to burn or gasify even a small proportion of their total output of this low-grade fuel, and its sale to outside consumers will become necessary.

Owing to the high percentage of incombustible matter, it will not pay to transport the material far from the mining centers where it is produced, but within a certain limited radius of five or ten miles, culm and washery refuse, when burnt under steam boilers or gasified in producers, form very valuable cheap fuels for power generation.

Special types of furnace grate and of gas producer are, however, necessary in order to obtain good results with these materials, and pertinent facts and figures are here given, based upon recent practical trials in England, America and Germany.

THE UNITED KINGDOM

The early attempts to utilize low-grade fuels for steam-raising in the United Kingdom were made in furnaces of the "destructor" type, for it was recognized that it would be impossible to obtain a decent evaporative efficiency from fuel, often containing from 25 to 35 per cent of ash, in the ordinary type of boiler furnace.

Goodrich, in the *Engineering Magazine* some years ago, pointed out that a Lancashire boiler with a grate area of only 38 sq. ft., could not possibly maintain its proper rate of efficiency with a fuel, the evaporative efficiency of which was at the best only 4 lb. of water per pound of fuel, and he proposed that the grate area should be doubled, and that compressed air should be employed to support the combustion. External brick cells with grate areas of from 50 to 75 sq. ft. were therefore provided, and under these conditions, with forced draft, an evaporation of 10,000 lb. of water per hour, with a Lancashire boiler measuring 30 by 8 ft., became possible. This Dutch-oven type of furnace, however, while quite useful for large sized material like "culm" and the "brasses" from hand-picked coal, was found to be impracticable when fine-grained material and the refuse from coke-washeries had to be burned, and the Bettington type of tubular boiler has now come to the front, as the most suitable for steam-raising purposes, with these classes of finely divided low-grade fuel. This boiler has often been described in the technical press, and some of the latest tests with it are recorded in the *Journal* of the Society of Chemical Industry (1917), p. 114.

Professor Cobb, however, in a paper read in April last before the Midland Section of the British Coke-Oven Manufacturers' Association, has pointed out that the Bettington boiler will require modification in some re-

spects before it can completely burn large-sized grains of coal and coke. The time during which the particles remain in the combustion zone of the boiler with the present design is far too short to allow of their complete combustion. The question of the best materials for the refractory lining of the boiler is also not yet settled, for the high temperature and the molten ash or slag combined have a most destructive action upon it. However, these difficulties will no doubt be overcome in time, and when they are the Bettington boiler will no doubt prove the most efficient type of steam producer, when fired with the finely divided waste materials from coal-cleaning plants and coke-washeries.

The coal-dust that accumulates upon the floors and edges of mines, and proves such an added danger when explosions occur, could also be collected and utilized for steam production if a battery of Bettington boilers were installed at or near the pit-head in all coal-mining districts.

Colliery Dumps Used for Gas Production

As regards the use of waste fuels for producer work in the United Kingdom, Fernald in Technical Paper No. 128 of the Bureau of Mines (published in 1915), gives some figures obtained from the manager of a large English colliery and iron works which had been equipped with a mechanically operated eccentric-grate gas-producer. Several types of producer have been designed for working with fuels high in ash content, and the more successful are provided with some form of revolving eccentric grate for removing the ash automatically, and for preventing blocks due to the formation of large masses of clinker in the lower part of the shaft. In the best form of these producers the degree of eccentricity and the speed of the grate can be varied to suit the amount and the fusibility of the ash formed by the fuel used.

In the particular case referred to above, a water-jacketed revolving-grate producer was installed for the purpose of utilizing the "batts" from the mine dumps of waste fuel, "batts" being the local term for the larger pieces of shale containing a good proportion of coal. It has been found in practice, however, that better results can be obtained by crushing the larger material, and by passing both the large and small through a washing-plant before charging into the producer. In this way the dump at this mine is being gradually reduced in size, 115 tons of the unwashed material yielding 60 tons of nuts (classified as Nos. 1, 2 and 3) and 40 tons of slack. The sample of the original waste-fuel taken from the dump tested as follows: Moisture 6.99 per cent, ash 52.12 per cent, volatile matter 18.37 per cent, fixed carbon 22.52 per cent, and the calorific value of the undried fuel was 5065 B.t.u. After washing, the fuel tested: Moisture 5.85 per cent, ash 24.60 per cent, volatile matter 28.75 per cent, fixed carbon 40.79 per cent, and the calorific value of the undried fuel had increased to 9869 B.t.u. The manager stated that the producers operated well with this washed material, and that their success in dealing with it was due to the water-jacket. The slag contained on an average only 4 per cent of combustible.

Coke Breeze or "Ballast" for Gas Production

In the publication referred to above, Fernald also gives some details of the utilization in England of coke "ballast," which is the name given to the "fines" produced when screening coke. The gases from the producers in this case were employed for firing brick kilns and were non-by-product producers, with stationary grates. The "ballast" used showed the following composition as regards size: 40 per cent passed through a $\frac{1}{2}$-in. sieve, 19 per cent was between $\frac{1}{2}$ in. and $\frac{1}{4}$ in., 14 per cent between $\frac{1}{4}$ in. and $\frac{1}{8}$ in., and 27 per cent was less than $\frac{1}{8}$ in. The analysis of this material gave the following figures: Moisture 10.77 per cent, ash 12.05 per cent, volatile matter 4.92 per cent, fixed carbon 72.26 per cent, calorific value, in B.t.u., 11,160.

The fuel was therefore not a low-grade fuel in the sense that the ash content was high, but simply on account of its fine state of subdivision. In recent years a considerable demand for this class of fuel has been created by electric power engineers, who use it for mixing with the cheaper varieties of bituminous fuel before burning this under steam boilers. This method of utilizing coke breeze was referred to in the second article of this series, printed in the issue of Metallurgical and Chemical Engineering for Sept. 1, 1917.

AMERICA

One of the most notable installations in America for utilizing the refuse coal from the washing plant attached to a large mine, is that erected by the Lehigh Coal and Navigation Company at Hauto, Pa., and described in *Electrical World* for May, 1914. This coal mining company mines in the anthracite coal area and places on the market the ordinary commercial sizes of anthracite. Although the calorific value of the refuse from the washing plant is from 9000 to 11,000 B.t.u., there is no profitable sale for it on account of the large proportion of dust it contains.

The original capacity of the power plant was 30,000 kw., but it is to be increased to 100,000 kw., and some idea of the amount of refuse to be dealt with can be obtained from the fact that in the production of the size known as "stove-coal" alone the Lehigh Company turns out enough refuse to run the whole of the enlarged plant. The original plant comprised eight Babcock and Wilcox double-ended units. Each boiler is provided with four grates, half of each set being fired from one side and half from the other. The boilers are of the five-drum bent-tube type, equipped with superheaters, and are designed to carry 225 lb. of steam pressure. Exclusive of the superheaters, each boiler has 10,000 sq. ft. of heating surface. Six of the boilers are equipped with hand-fired dumping grates of special design, and the two remaining units are equipped with automatic traveling grates, a development of the Coxe design. In the case of the hand-fired furnaces the grates are 12 ft. deep and 8 ft. wide, making the total grate area 384 sq. ft. per boiler. Four of the boilers are provided with Acme slotted-top grates and two are equipped with pin-hole tops. In each case about 6 per cent of the total grate area is occupied by air-apertures, the holes or slots being about 3/32 in. wide. The apertures are at the bottom of grooves moulded across the grate-tops, at right angles to each other, giving the appearance of a waffle-iron. The grooves are provided in order to prevent the fine coal from choking the apertures and thereby hindering free circulation of air through the furnace. Other features of the furnace are the use of vertically sliding furnace doors, recessed ash-pit doors, and shaker-

handles to prevent obstruction to the firing aisles, double fire-arches, cinder catchers, ventilation of fire-wall to prevent burn-outs, and independent brick-settings which are not affected by expansion of the metal parts. Double superposed fire-arches are provided so that if the lower one burns out, the upper one will come into use. Between the superposed arches is an air-space through which air is allowed to circulate slowly, in order to prevent the firebrick temperature from reaching such a value that the material deteriorates. The space over the grates is practically a reverberatory furnace, which ensures the complete combustion of the fuel. The fire-arch is 9.5 ft. long and covers two-thirds of the grate-area. The combustion-chamber above the brick wall is unusually large, and is so designed as to reduce the velocity of the gases and allow any unburned fuel to drop back into the fire and be consumed. The gases from four furnaces under each boiler pass up through the central combustion-chamber and then divide at the top, going through two passes, striking the flues and superheaters (of which there are two to each boiler) and then following the vertical uptakes at the boiler heads to the roof of the station, where they join a common stack. Whatever unburned fuel or cinder may be carried over into the first pass of the boilers is thrown out by centrifugal force at the bottom of the pass into a cinder-catcher. The steam is employed to drive three turbo-generators, each of 12,500 kw., generating current at 11,000 volts. When running at their full load and maximum efficiency, these units consume 12.3 lb. steam per kw.-hr. with a vacuum of 28 in. The electric energy is transmitted at 110,000 volts to various coal mines and cement mills located in the vicinity of the Hauto supply station. The transmission line, however, has been designed for long-distance work, and possibly in time the cities of New York and Philadelphia may receive current from this waste-fuel electricity supply station.

Another example of an American coal-mine electric power-station which is using waste-fuel for steam-generation is that provided by the plant of the Cadogan Mine in Armstrong County, Pa., a detailed description of which was published in *Coal Age* on Dec. 2, 1916.

The fuel in this case consists of 50 to 75 per cent refuse from the tipple picking-tables, mixed with slack. The boilers are Heinz watertube boilers, rated at 470 hp. at 150 lb. working pressure, and provided with a grate-area of 84 sq. ft. Each boiler is fed by three mechanically-operated underfeed stokers, forced draft being supplied by one blower-fan driven by two direct-coupled steam engines. The ash is removed by steel cars running on rails directly below the discharging holes of the retorts. The generating plant consists of two 375-kw. alternators coupled direct to Corliss valve steam engines running at 150 r.p.m. These engines consume 21.6 lb. per hp.-hr. at full load, 21.3 lb. at three-quarter load, and 21.8 lb. at half load. The energy developed is used chiefly for cutting, haulage and pumping purposes at the mine, but as transmisison is an important point, it is generated at 2,300 volts, and is converted by motor-generator sets to direct current at 250 volts at the various points where it is required.

The general conclusions that may be drawn from American experience and practice with these low-grade fuels are two: First, it is recognized that some form of artificial draft is requisite for the proper combustion of the smaller sizes of fuel waste, forced fan-draft operated on the "balanced-draft" principle being most favored. Secondly, it has been proved that only in exceptional cases will it pay to grind or pulverize the lump waste fuel in order to burn it in dust form. When the fuel is brought to the surface in this finely divided state this method of burning is, of course, the most efficient, but in nearly all cases the fuel is too poor to pay for the cost of artificial pulverization. The heat produced by burning rich "culm" in the dust form is sufficient to melt all forms of refractory material, but this is an exceptional material, and the greater number of waste fuels contain so large a proportion of ash that when burnt in the dust form the temperature produced is not so high as that attained under ordinary conditions with lump fuel.

GERMANY

Experimental trials were carried out by Butow & Dobblestein in 1910-1911 for the Westphalian Mine Owners' Assoication in connection with the utilization of waste fuels at the mines, and a summary of the results obtained and conclusions reached has been published from time to time in the German mining paper *Glückauf*. Butow and Dobblestein state that low-grade fuels may be classified according to their origin as follows: (1) Coarse-grained material with ash content up to 50 per cent and water up to 20 per cent; (2) fine-grained material with ash content up to 40 per cent and water up to 30 per cent, and (3) small-coke and coke-breeze with ash content up to 30 per cent and water up to 20 per cent. Two methods of utilization for these low-grade fuels are open to the engineer: they may be burned under steam boilers either alone or in conjunction with other materials, or they may be gasified in producers. Fuels of class (1), they assert, can be burned directly without admixture with other material, but the steam-raising efficiency of the boiler is very low, and such fuels can only be employed in large boiler installations. The application of forced draft gives very little advantage in the case of these fuels, and their utilization directly for steam-raising purposes is therefore restricted to special cases. Fuels of classes (2) and (3), when they can be obtained, yield the best results when fired together, this being specially the case with the fine coal from a rich or gas-coal and coke-breeze, which together yield an excellent firing material for steam boilers. In this case the use of forced draft increases the efficiency of the firing. As regards fuels of class (3), Butow and Dobblestein state that these can be fired alone if they contain 10 per cent of volatile matter and if forced draft is available. Coke-breeze containing less than 10 per cent of volatile matter cannot be fired alone, however, and if no fine material from a rich or gas-coal is available for mixture it must be briquetted with the aid of pitch. Should the ash and water contents of the breeze exceed 30 per cent it will not pay, however, to briquette it, and for this material, as for the lowest grades of classes (1) and (2), gasification in producers is the only practicable method of utilization.

In a later report the same two engineers give details of steam-raising tests made in July, 1911, at the mine "Prosper," with low-grade fuels and a traveling-grate stoker. Fuels containing from 9 up to 22 per cent ash and from 2 up to 13 per cent water were used in these tests. The fine coal from the coal-washing plant and the

coke-ashes could in neither case be burned alone, and were in the final tests either burned together or mixed with the other fuels. A Dürr boiler possessing a heating surface of 1640 sq. ft. was employed in the tests. Six tests were made with the following products: (1) Rejected fuel from the washing-plant. (2) No. 1 fuel mixed with coke-ashes in the proportion of 2 to 1. (3) Dust from nut coal mixed with coke-ashes in the proportion of 3 to 1. (4) A mixture of two parts of fine coal-dust with one part of coke-ashes. (5) A mixture of equal parts of fine coal-dust and rejected fuel from the washer. (6) Dust from nut-coal alone. The following results were obtained: Pounds of steam obtained per pound of fuel burned—(1) 5.61, (2) 4.96, (3) 4.16, (5) 4.45, (6) 5.55. Boiler efficiencies—(1) 58.96, (2) 53.18, (3) 42.93, (5) 48.74, (6) 55.95. The cost of 1 ton of steam using rejected fuel from the washing-plant, was only 18 cents, of which total fuel represented 12 cents.

As regards the use of these waste fuels for gasification, Butow and Dobblestein state that the chief difficulty encountered has been the bulk of the slag and ashes which have to be removed, and the tendency of this to fuse together into large masses and to disturb the normal working of the producer. The producers experimented with were (1) the Mond producer and (2) the Erhardt and Schmer producer. Coke-ashes containing 19.4 per cent ash and 20.7 per cent moisture were used. The trial of the Mond producer with this fuel failed, owing to the air-pressure required to burn it being sufficiently great to blow out the water-seal. So far as could be judged from the preliminary results of the test, 35 cu. ft. of gas testing, 112 B.t.u. per cubic foot, would cost 4.7 cents, without any allowance for labor, depreciation or interest charges.

The trials with the Erhardt and Schmer generator were more successful, as this producer possesses a rotary hearth which retained all the fuel in the lower part of the charge in continual motion and thus prevented clinker formation. In this case a mixture of equal proportions of coke-ashes and refuse from the washing and sorting machines at the mine was used, and after the method of burning the generated gas under a Lancashire boiler had been modified very successful results were attained. The following is an estimate of the cost of evaporating 2204 lb. of water with this cheap fuel-refuse:

Labor	9.6 cents
Interest and depreciation	9.6 "
Fuel	6.0 "
Feed water	1.2 "
Power for motor	1.6 "
Total	28.0 cents

For a larger plant this low cost could be still further reduced, as the same labor would suffice for two producers, and 2204 lb. of water could then be evaporated for 24 cents. By use of the gas in a gas-engine, still more favorable results could be attained.

Finally, a report made by Mann and Müstefeld upon the gasification of low-grade fuels, and published in *Glückauf* in 1912, may be referred to. These authors state that the chief characteristic which determines whether a fuel is to be classed as "low-grade" is the fineness of its particles; ash and moisture are of secondary importance. The factors that determine whether any particular low-grade fuel will pay for its gasification are (1) the chemical composition of the gas that can be produced from it, and (2) the cost of obtaining one calorie, or heat-unit, in the gas produced. The chief difficulty in working gas-producers with these low-grade fuels is due to the finely divided state of the particles. This causes great resistance to the air supply inside the producer. Incomplete combustion occurs in consequence and the yield of gas is diminished. Air-channels are also formed in the burning mass of fuel which lead to further disturbances of the normal conditions of work, since these air-channels carry an excessive air-current and result in the formation of CO_2 in place of CO.

The authors give details of trials made with the Mond, Erhardt and Schmer, Maschinen Fabrik Augsburg, and with the Kerpely producers, when using this class of fuel. The steam required to operate the different types of generator varies from 15 to 18 lb. per 100 lb. of fuel in the case of the Kerpely producer, up to 200 lb. in the case of the Mond producer. The Kerpely high-pressure producer is finally described in the form specially designed for gasifying finely divided low-grade fuels. A satisfactory gas composition is obtained from these producers by the use of a great depth of fuel-bed and by a uniform distribution of the air-supply over the whole area of the combustion zone. The ashes and clinkers are continuously removed as the gasification of the fuel proceeds. The following tests show the chemical composition of the gas made in a Kerpely producer during six separate trial-runs.

	1	2	3	4	5	6
CO_2	3.00	5.18	10.0	7.0	2.4	4.1
CO	30.20	26.66	21.9	27.4	32.5	29.5
H	14.85	15.01	22.2	18.3	12.3	14.5
CH_4	.40	1.30	2.0	2.5	.....	1.4

In conclusion, it may be pointed out that the subject of the utilization of these low-grade fuels has a far wider bearing upon the future of American manufacturing industries than is generally recognized. At present from 20 to 35 per cent of the fuel reserves are being left in the mines, because there is no market for the poorer classes of fuel.

Those who imagine that the poorer seams of coal can be worked and brought to the surface when all the richer seams have been exhausted only show their ignorance of mining operations by this belief. It is therefore incumbent upon all who have the future welfare of their country at heart to study the methods of utilizing low-grade fuels, and to do what is possible to create a market for them while the seams are still exposed and their extraction from the mines is a practicable proposition.

Colwyn Bay, North Wales.

New York State Branch of American Ceramic Society.—A meeting was held in Hornell, N. Y., on Nov. 19 and 20 for the organization of a New York State Branch of the American Ceramic Society. The following officers were elected for 1918: President, L. E. Barringer, Schenectady; vice-president, Frederick Carder, Corning; secretary, J. B. Shaw, Alfred. It was decided that a meeting should be held quarterly, the next meeting to be called in May at either Syracuse or Schenectady.

A Volume Regulator for Blast-Furnace Engines*

By L. C. Loewenstein

BLAST-FURNACE operation has attained a high degree of refinement in the proportioning of the various materials composing the charge—the ore, the fuel and the flux. The weight of oxygen—introduced as atmospheric air—per charge has, however, until recently been subject to much uncertainty due primarily to the difficulty of measuring with any degree of accuracy the volume of air delivered. The adjustment of the air supply to the furnace was, therefore, usually made only when the operator found evidence that the furnace was badly overblown or underblown, a process which resulted in a more-or-less variable product and certainly in a reduction in the possible maximum output of the furnace.

With the advent of the centrifugal compressor giving a perfectly steady air blast, the metering of the air supply became more practical and, therefore, more usual. With perfectly definite and uniform charging a definite and uniform weight of air per minute is desirable. Constant-volume governors have been designed on two principles, one by metering the air by means of a venturi meter and the other by using an impact float. The venturi-meter governing has been improved by using a multiple venturi meter in which large pressure drop can be obtained in the throat without a corresponding loss in power. This difference in pressure is used on a mercury pot whose motion up and down is translated to the governing mechanism of the driver of the air compressor. The proper setting of this meter is accomplished by changing the tension of the spring until a scale calibrated in cubic feet of air per minute shows that the desired quantity of air is obtained.

In the impact float method the air is taken through a conical opening in which is suspended a float, this float moving a horizontal beam about a pivot. The horizontal beam actuates the governing mechanism of the driver of the air compressor. On this horizontal beam is a sliding weight which can be set at calibrated marks representing cubic feet of free air per minute. With the weight set in a definite position a certain definite quantity of air is obtained.

In both of these methods, however, the readings on the calibrated scale are only correct when the initial air conditions are standard, that is, are similar in barometer, temperature and humidity to which the scale has been calibrated. Any change in either the temperature of the inlet air or in the atmospheric barometer or in the humidity of the air, changes the weight of the air metered, and, therefore, its oxygen content. As the blast furnace requires an exact weight of oxygen, the above method of holding constant volume is liable, in extreme cases, to have an error of from 15 to 20 per cent.

The Volume Corrector

A volume corrector is herewith presented which when used in connection with the air-metering device will correct for any changes in either temperature, barometer and humidity, so that the air supplied to a blast furnace will, at all times, under any atmospheric conditions, deliver a perfectly definite and predetermined weight of oxygen to the blast furnace. This volume corrector is so designed that it requires only one setting for each correction, that is, one setting for any initial temperature, one setting for any existing barometer and one setting for humidity as usually obtained by the difference of readings on a wet-and dry-bulb thermometer.

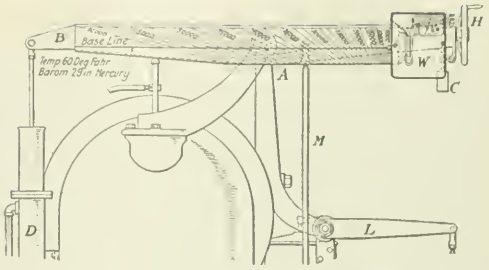


FIG. 1. VOLUME CORRECTOR APPLIED TO IMPACT FLOAT GOVERNOR

It can be applied to the sliding weight and calibrated scale of an impact-float constant-volume governor for correcting this governor when handling air of any temperature, barometer or humidity. An instrument similar in principle and somewhat similar in construction can also be applied to the indicating mercury column of the venturi meter so as to obtain proper volume correction.

The volume corrector applied to the impact-float constant-volume governor is shown in Fig. 1. The scale beam *B*, instead of having vertical calibration lines for standard conditions of air, has sloping constant-volume lines engraved upon it. The volume corrector proper is mounted on the front of the sliding weight *W*.

Fig. 2 shows the arrangement of this instrument. There are three milled heads, *A*, *B* and *C*, provided for

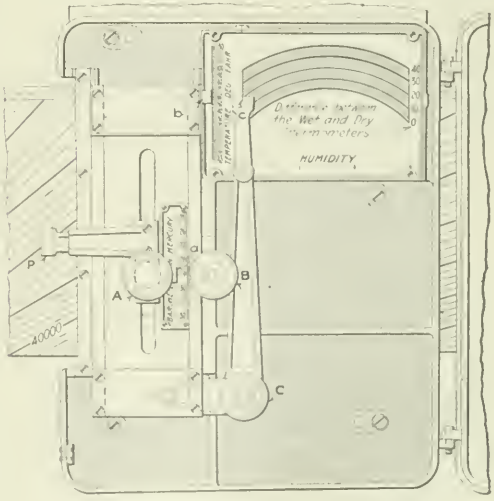


FIG. 2. INTERIOR CONSTRUCTION OF CORRECTOR

*Abstract of a paper presented at the annual meeting of the American Institute of Mechanical Engineers, December, 1917.

adjusting pointers indicating barometer, temperature and humidity. All that is required of the operator is to set these pointers correctly. After obtaining the actual barometer reading from a standard barometer, and the actual temperature of the incoming air, and observing the existing humidity—which is usually done by noting the temperature difference between a wet- and dry-bulb thermometer, pointer *a* is set at the proper barometric reading, pointer *b* at the proper temperature reading, and pointer *c* moved so as to intersect the curve corresponding to the observed temperature difference between the wet- and dry-bulb thermometers.

The movement of each of these pointers influences the final position of the main pointer *P*. This main pointer moves in a vertical direction with respect to the scale on the beam. After the volume corrector is properly set, the sliding weight to which the volume corrector is permanently attached is moved horizontally along the beam until the main pointer *P* intersects the sloping line on the graduated scale designating the proper volume of standard air required. When so set the sliding weight is in the proper position. This permits corrections to be made for variation in temperature, barometer and humidity so that a constant *weight* of oxygen is supplied no matter what the conditions of the atmospheric air. Having determined that the blast furnace requires a definite volume of standard air (dry air at 60 deg. Fahr. and 29 in. Hg), the governor with corrected setting of the sliding weight will deliver the proper amount of actual air which would contain the same *weight* of oxygen as would be contained in the required quantity of standard air.

Principles of the Corrector

The amount of oxygen in dry air varies directly as the density of the air. The density of air is directly proportional to the barometric pressure and inversely proportional to the absolute temperature. Expressed symbolically, $\gamma \propto \frac{B}{T}$. As the float force is proportional to $\frac{M^2}{\gamma}$, a change in density γ with the governor set to maintain a constant weight M of air per second will cause the governor to change the speed of the compressor until a new weight M_1 is delivered, such that the new value of $\frac{M_1^2}{\gamma_1}$ is the same as the original value of $\frac{M^2}{\gamma}$. Expressed symbolically, for a given setting of the sliding weight $M^2 \propto \gamma$, or $M \propto \sqrt{\gamma} \propto \sqrt{\frac{B}{T}}$. For moist air the barometer no longer represents the pressure of the air itself, for part of the barometric pressure is due to the vapor pressure in the air. This vapor pressure must therefore be subtracted from the observed barometric pressure in order to get the net air pressure to be used in computing the air density and hence the weight of oxygen per cubic foot of air. For saturated air (a relative humidity of 100 per cent) the vapor pressure can be read directly from steam tables for the observed atmospheric temperature. If the air is not quite saturated the relative humidity, or the percentage of the possible maximum of moisture in the air, can be determined in a number of ways; usually, from a dry- and wet-bulb thermometer arrangement. The vapor pressure for a given temperature is proportional to the relative humidity, and this must then be subtracted from the observed barometric pressure in computing the air density.

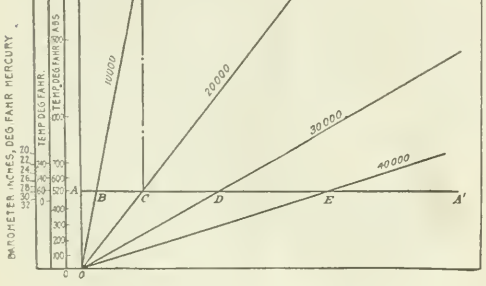


FIG. 3. METHOD OF GRADUATING BEAM

The graduated scale on the beam of the constant-volume governor was designed by taking a horizontal base line such as shown schematically in Fig. 3 as *AA'*, and placing thereon the proper calibration for standard air (dry, 60 deg. Fahr., 29 in. Hg.). The zero on this line gives the position of the sliding weight when the constant-volume governor beam is in equilibrium and no air is flowing. The point *B* (Fig. 3) represents the position of the sliding weight for 10,000 cu. ft. flow; and point *C* its position for 20,000 cu. ft. flow, etc. The distance *AC* is made equal to four times *AB*. Similarly the distance *AD*, where *D* represents the 30,000 cu. ft. point, is made equal to nine times *AB*. With respect to temperature, the graduations on the *AA'* hold good so long as the prevailing atmospheric temperature is 520 deg. Fahr. absolute. When the prevailing temperature is other than 520 deg. Fahr. absolute, the relations of the distances *AB*, *AC*, *AD* to each other remain unchanged; but they must all be multiplied or foreshortened by the same ratio. This is accomplished in the following manner:

Referring to Fig. 3, let the line *OAB'* be perpendicular to the base line *AA'*; and let *OA* represent to some scale 520 deg. Fahr. absolute, and *OB'* represent 2080 deg. Fahr. absolute to the same scale, so that *OB'* = 4 *OA*. Draw *B'C'* parallel to *AA'* and *CC'* parallel to *OB'*. Also prolong the straight line *OB* until it intersects the line *B'C'* in the point *P* (not shown). The triangles *OAB* and *OB'P* being similar, *B'P* : *AB* : : *OB'*:*OA*; or *B'P* = 4 *AB*. But *B'C'* = *AC* = 4 *AB*. Therefore *B'P* = *B'C'*; or *P* coincides with *C'*. In other words, the intersection *C'* of the line *CC'* with *B'C'* is a point on the straight line OB.

Now in actual operation, when the governor is set to deliver 20,000 cu. ft. of standard air per minute for a temperature of 520 deg. Fahr. and should the actual temperature be four times as high, or 2080 deg. Fahr. absolute, the governor will, as explained before, with the same setting of the sliding weight, regulate for only 10,000 cu. ft. of standard air per minute, because the density of the air at 2080 deg. Fahr. absolute is one-

fourth of that at 520 deg. Fahr. absolute. The pointer of the sliding weight must under those conditions then read 10,000 cu. ft. without the sliding weight itself being disturbed in any way. In the volume corrector this would be accomplished by pushing up the final pointer along a uniform temperature scale until it reads 2080 deg. Fahr. absolute, because the pointer traveling upward would then, as proved above, just intersect the 10,000 cu. ft. line *OBC*. It will be noticed that all the sloping lines representing definite volumes of air per minute meet at *C*. This would represent the point of absolute zero if the same temperature scale was carried down on the prolongation of the line *AB*. From the above it can be seen that if the volume corrector be made to carry a temperature scale with the same distances as employed in the engraving of the scale on the beam, and the main pointer *P* of the volume corrector be made to move vertically up and down the proper distance to this scale, the sliding weight can be set for any observed temperature of atmospheric air so as to deliver the proper volume of air containing the same weight of oxygen as is contained in the previously calculated necessary volume of air of standard conditions.

Further consideration will show that as far as the density or the square of the volume is concerned, doubling the absolute temperature is equivalent to halving the barometer. In other words, any barometric change can be expressed by an equivalent temperature change. For instance, if 29 in. Hg is taken as the standard barometer and 60 deg. Fahr. (520 deg. absolute) as the standard temperature, a change to 28 in. barometer, the temperature remaining at 60 deg. Fahr., is equivalent to a change to a temperature $\frac{29 \times 520}{28}$ or 538.6 deg. Fahr. absolute (78.6 deg. Fahr.) with the barometer remaining at 29 in. Hg. The distance on the barometer scale from 29 in. to 28 in. must, therefore, equal the distance from 60 deg. Fahr. to 78.6 deg. Fahr. on the thermometer scale, whereas the correction necessary from 29 in. Hg to 25 in. Hg barometer is equivalent to a change to a temperature of $\frac{29 \times 520}{25}$ or 603.2 deg. Fahr. absolute (143.2 deg. Fahr.) with the barometer remaining at 29 in. Hg. The distance on the barometer scale from 29 in. to 25 in. must therefore equal the distance from 60 deg. Fahr. to 143.2 deg. Fahr.

The barometric scale constructed on the above principle for the volume corrector is evidently a reverse and reciprocal (that is, non-uniform) scale. For constructional reasons, and chiefly to take care of humidity corrections explained later, it is desirable to have this scale uniform without affecting in any way the accuracy of the instrument. This is accomplished in the following manner:

Referring to Fig. 4, which gives a view of the volume corrector shown in Fig. 2, but with some of the front cover plate removed, *A*, *B* and *C* are the pins to which the milled heads *A*, *B* and *C* are attached. The main pointer in Fig. 2 is moved up and down in a vertical slot by means of pin *p* in Fig. 4. When the operator moves milled head *A* so that pointer *a* indicates the barometer reading, gearwheel *D* (Fig. 4) rotates about pin *A* because it is meshed into a rack *E* which remains stationary. Motion is given to pin *p* (which is held in vertical slot) by the slot *S* in gearwheel *D*. This slot is in the form of a cam and so designed that pin *p*, and therefore the main pointer *P*, moves the proper distance vertically. The main pointer will move a less distance vertically when barometer pointer moves from 32 in. to 31 in. than it will when moving from 31 in. to 30 in., and less from 31 in. to 30 in. than it will from 30 in. to 29 in. Therefore, although the barometer scale over which pointer *A* moves has uniform divisions, the actual vertical distance through which the main pointer *P* moves is non-uniform and follows a reciprocal scale.

The setting of temperature is accomplished through milled head *B*, which is attached to a plate movable vertically between gibs *GG* and which carries with it the rack *E*, gearwheel *D*, and pin *p* with main pointer *P*. Moving *B* up and down does not revolve gearwheel *D* at all (that is, does not disturb the barometer setting), but simply moves main pointer *P* over a temperature scale shown in Fig. 2. Pointer *b* is set opposite the proper temperature reading.

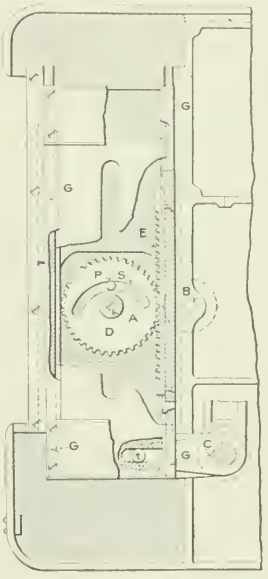


FIG. 4. INTERIOR END OF REGULATOR

The corrections for humidity in the volume corrector are based upon the following considerations: The barometric - pressure reading as usually observed is equal to the sum of the air pressure plus the vapor pressure. If the air is saturated, that is, if it contains all the water vapor it is capable of holding without precipitation at the particular temperature, the value of the vapor pressure at the given temperature can be ascertained experimentally or taken from the steam tables. If the degree of saturation or the relative humidity is, say, only 20 per cent or 50 per cent, then the vapor pressure as determined experimentally must be multiplied by 0.20 or 0.50 as the case may be.

The most usual method of ascertaining the relative humidity of the air is by means of a wet- and dry-bulb thermometer arrangement. In its simplest form it consists of two similar thermometers, the bulb of one of which is covered by a wet piece of sponge. If the air is fully saturated no evaporation into it can take place and the two thermometers record the same temperature. When the air is only partly saturated, the evaporation from the wet bulb lowers the thermometer reading; so that the difference in the readings of the wet and dry thermometers can be taken as a measure of the relative humidity of the air. For any combination of relative humidity and atmospheric temperature the vapor pres-

sure is a definite quantity. This vapor pressure must be subtracted from the observed barometer reading in order to give the net or correct air pressure to be used on the barometer scale above described; since it is the density (and therefore the actual pressure) of the air alone that is of importance, and not the density of the mixture of air and water vapor.

It is important to note that the humidity correction in pounds per square inch or in inches of mercury is independent of the actual barometer reading, and depends only on the atmospheric temperature and on the difference between the wet- and dry-bulb thermometer readings (relative humidity). The humidity correction can therefore be made mechanically if the pointer *P* on the sliding weight is given an additional correction or movement which would be the equivalent amount of a certain subtraction of pressure on the barometric scale equal to the correction for the pressure due to vapor. It is for this reason that it is preferable to make the divisions on the barometric scale uniform, so that, for instance, a half-inch mercury correction would require the same movement no matter at what reading the barometer scale happened to be set. As will be shown later, the volume corrector accomplishes this, therefore no matter where the barometer pointer *a* is set, the humidity correction moves the main pointer *P* on the sliding weight the proper amount. It will also be noticed that the humidity is a function of the atmospheric temperature, that is, when the temperature is high the water vapor in the saturated air is higher than when the temperature is low. In the volume corrector the setting of the temperature pointer *b* on the temperature scale automatically sets the humidity pointer *c* to the correct temperature also.

Referring to Fig. 2, the correction for humidity is made by loosening milled head *C* and swinging pointer *c* until it intersects or indicates the proper amount of difference in reading between the wet- and dry-bulb thermometer. The movement of the long arm carrying pointer *c* about the center of milled head *C* moves pin *t* attached to a plate carrying gearwheel *D*, but does not move rack *E*. Moving gearwheel *D* vertically up or down rotates *D* because *E* is stationary and thereby moves the main pointer *P* similarly, as heretofore described.

Accurate Constant-Volume Governing

The volume corrector therefore is an instrument which can be set by an operator at the existing barometer, temperature and humidity of the atmospheric air, and when so set will permit the setting of the sliding weight on the scale beam in a position so that the constant-volume governor will hold or deliver the correct volume of air which would contain the same weight of oxygen as would be contained in a certain predetermined and desired volume of standard air.

This means that the blast-furnace operator, knowing the chemical compositions of the coke and iron ore and the amounts charged to the furnace in a stated period of time, can determine the exact volume of standard air (dry, 60 deg. fahr., 29 in. Hg) which will contain the proper amount of oxygen necessary for combustion of the coke and reduction of the iron ore on the blast furnace. He need not perform any mathematical calculations as to how much more or how much less air must be supplied when the atmospheric conditions are not those considered standard in order to be sure the blast furnace is receiving at all times its exact and necessary weight of oxygen.

The volume corrector needs resetting every time the operator notices any change in the barometer, temperature or difference between the wet- and dry-bulb thermometer reading in order to be sure of securing the most efficient regulation. The air conditions, however, do not vary rapidly and the practice of inserting in an engine-room log every half hour the steam pressure, r.p.m., vacuum and other information can easily be extended to include readings of the barometer, thermometer and wet- and dry-bulb instrument. Even with the front cover of the volume corrector closed, transparent places are provided which will permit any one checking or observing these settings. The need of a volume corrector is apparent from the fact that it is possible to have a variation of weight of oxygen delivered to a furnace of 5 to 10 per cent ordinarily and in extreme cases as high as 20 per cent as a result of variations in atmospheric-air conditions, especially as between winter and summer. The gains in quality and quantity of output of a blast furnace obtained even by the former methods of constant-volume governing without volume corrections will be still further improved by the use of constant-volume governing with proper volume corrections.

West Lynn, Mass.

Close Watch on German Trade Preparations.—German preparations for trade after the war are being scrutinized carefully by experts in the Bureau of Foreign and Domestic Commerce, and the recent important report on the subject of "German Foreign Trade Organization," by Chauncey D. Snow, which touched on this point, has been in great demand. Since the war eliminated Germany from world trade, the United States has improved its position in foreign markets in spite of the shipping shortage and other abnormal restrictive factors. Department officials point out that the future prosperity of the country will depend in part on Germany's loss of good-will in practically all foreign markets and in part upon American ability to maintain our new prestige. American business must not make the mistake of seeing only one side of this situation and thus underestimating the German capacity for foreign trade or the energy, application, and craft with which German business will address itself to the task of regaining favor in markets in which it once prospered. In order to understand the significance of the information on German trade moves that will from time to time be made public, Secretary Redfield counsels not imitation of but familiarity with the German theories of foreign trade and the artful and formidable organization that, with Government aid at every turn, has been built up in Germany during the last twenty years to dominate the world's markets. It was to meet the demand for such information that the Bureau of Foreign and Domestic Commerce issued the bulletin on "German Foreign Trade Organization." The unprecedented demand for it is taken as an indication that the American manufacturer is making after-war preparations of his own. The Bureau now plans to get out about the first of the year a supplementary bulletin on German trade and preparations for the commercial future.

Bibliography on the Extraction of Potash

From Complex Mineral Silicates, Such as Feldspar, Leucite and Glauconite (Greensand Marl)

By E. C. BUCK

LESS progress has been made in the production of potash from silicate rocks than from other natural resources, such as brines and kelp. Nevertheless, a vast amount of work has been done on the subject and numerous processes have been patented. It is believed that the following bibliography will prove timely. It includes all references to patents and periodical literature relating to the sintering of phosphatic rocks with feldspathic rocks—a process which is held to be of great promise, since the potash is at once obtained in combination with the phosphoric acid. Other methods and processes have been included without partiality, and the list is practically complete.

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(To be concluded)

Synopsis of Recent Metallurgical and Chemical Literature

The German Chemical Industry.—*The Chemical Trade Journal and Chemical Engineer* (London) prints an interesting editorial in its Nov. 17, 1917, issue on recent developments in the large chemical companies in Germany. It is stated that a German report says that transactions on the Berlin Stock Exchange have recently been particularly active in shares of the companies engaged in the heavy chemical industry, with large upward movements in the quotations. In connection with this state of affairs rumors are in circulation to the effect that the question of largely increasing the share capital is engaging the attention of the leading concerns which entered into the enlarged community of interests in May, 1916, when the ordinary share capital of the three leading firms in the community—the Farbwerke Hochst, the Badische Anilin und Soda Fabrik, and the Farbenwerken vorm. Bayer & Co.—was rendered uniform on the basis of £2,700,000 each. No information appears to be forthcoming at present as to the projected capital augmentation, but it is considered probable that some such scheme is definitely proposed, having regard to the large extensions of the plants which are reported to have been carried out during the course of the war. A further factor in connection with the rumors is the statement that the present great community of interests is to be extended by the inclusion of other chemical firms.

The intention of the German Government to introduce compulsory syndicates, where such combinations do not exist and where voluntary efforts in this direction fail to accomplish the object in view, has now engaged the attention of the chemical industry. At the recent assembly of the Association for the Protection of the Interests of the Chemical Industry, which was held at Berlin, under the presidency of Dr. Hauser of Hochst, Dr. Riesser of Berlin, raised the question of the transition economy from war to peace work, and expressed his opposition to any compulsory syndicate in the chemical industry in that connection. If the central regulation of imports was inevitable, the chemical industry should be allowed to manage for itself and State limitation be restricted to supervision. It was necessary for freedom of trading to be restored to the fullest extent. The chemical firms, he said, desired to remain what they were—members of the creative class, without guardianship in their activity for the welfare of the country.

Effects of Heat on Celluloid.—The Bureau of Standards has recently issued Technologic Paper No. 98 by H. N. STOKES and H. C. P. WEBER on the effects of heat on celluloid and similar materials. The general conclusions from the work are as follows:

1. Celluloid (using the term in its popular sense to include the pyroxylin plastics in general) does not differ essentially from nitro-cellulose. The difference is one of degree and not of character. Nitrocellulose exists and reacts in celluloid as such; that is, as a solution of nitrocellulose in camphor or other solvent present, rather than as a new chemical compound. The admixture up to 20 per cent of zinc oxide does not decrease the rate of decomposition of the nitrocellulose in celluloid, the results seeming rather to show that there is an increase.

2. The decomposition of nitrocellulose in celluloid commences in the neighborhood of 100 deg. C. Above this tempertaure the heat of decomposition may raise the temperature of the mass to the ignition point, if loss of heat by radiation is prevented.

3. Above 170 deg. the decomposition of celluloid takes place with explosive violence, as with nitrocellulose.

4. The rate of combustion is five to ten times that of poplar, pine, or paper of the same dimensions and under the same conditions.

5. Celluloid articles may be ignited by momentary contact with bodies having a temperature of 430 deg. or above, i.e., temperatures below visible red heat.

6. In spite of wide differences between individual samples, no essential differences were found between the celluloids of American manufacture, nor between articles of American and foreign manufacture, nor between manufactured and unmanufactured articles.

7. The general qualities of celluloid as to stability may be best expressed by a time-temperature curve, taking the time necessary for exploding small samples at several temperatures, say 170 deg., 180 deg., 200 deg. and 220 deg.

8. The vapors evolved by decomposition are poisonous and extremely combustible and may be ignited by the heat of decomposition of the celluloid itself.

9. The decomposition of celluloid is autocatalytic, and while not necessarily explosive may readily approach that condition as a limit.

Chemically Pure Bismuth.—Bismuth at present is commercially manufactured with a purity of 99 per cent, and for all ordinary purposes this is sufficient. However, in the manufacture of electric and magnetic measuring instruments, for which bismuth is used in ever-increasing quantities, a much purer metal is required. M. MYLIUS and E. GROSCHUFF describe a very satisfactory process of refining bismuth, in the *Zeitschrift für Anorganische Chemie.*

The authors call attention to the fact that while a 99 per cent pure metal is obtained fairly easily, the remaining 1 per cent of impurities holds so tenaciously as to make its removal somewhat difficult. By heating the nitrate of bismuth, $Bi(NO_3)_3 + 5H_2O$, the oxide is formed and this can be reduced by hydrogen. The residue is melted and crystallized. The plan to purify bismuth by distillation does not work out in practice, as most of the impurities remaining after the ordinary refining process boil at a temperature of less than 1500 deg. Cent., which is the temperature of boiling bismuth.

The method described above is stated to yield a metal which does not contain more than 0.01 per cent of impurities and which melts at 271 deg. Cent. Wire of 1 mm. diameter has an electric resistance of 1.20 ohm. at 22 deg. If the percentage of impurities amounts to 0.1 per cent the resistance value is 3 ohms.

The Determination of Titanium in Ferro-Titanium.—An improved method of analyzing volumetrically the quantity of titanium in ferro-titanium has been discovered by G. ROEHL and described in the *Chemiker*

Zeitung. It is an improvement of the titration method evolved by Knecht and consists of the following operation: The strongly acid solution of ferro-titanium is reduced to a titanium chloride solution by the use of zinc and a current of CO_2. This reduced solution is then titrated with a hot solution of $FeCl_3$ in the presence of several drops of methylene blue. The color change is extraordinarily sensitive.

As the most satisfactory proportions the author recommends that 0.5 gram of the finely pulverized product be treated with 5 to 6 times its own weight of "Eschka alloy" to melt this mixture and then drop on it a very small quantity of water. Dissolve the whole by boiling in 200 cc. of concentrated hydrochloric acid. The solution is poured into a vessel of larger contents and water is added to make 500 cc., 100 cc. being used for each titration. To each 100 cc. is added 60-70 cc. of concentrated HCl and 4 or 5 zinc granules. A current of CO_2 is sent through the solution. When the reduction is complete the current of CO_2 is shut off, methylene blue added and the solution titrated with a hot solution of $FeCl_3$ of accurately known strength, tested on solutions of titanium oxide (TiO_2) prepared for that purpose.

Synthetic Rubber.—The Catalyst, official organ of the Philadelphia Section of the American Chemical Society, gives an abstract of an address delivered before the Section by Dr. FREDERICK DANNERTH of Newark, N. J., on the "Financial Prospects of Synthetic Rubber."

In his introductory remarks, Dr. Dannerth referred to the various attempts which have been made in England and America since 1909 to float companies for the manufacture of synthetic rubber. Many of these bore a close resemblance to stock-jobbing propositions. The only bona fide processes thus far recorded, and which actually demonstrated progress in the art, were those of the Synthetic Products Co. of England and the chemical works at Elberfeld and Ludwigshafen. The English company is at present handicapped by its overproduction of butyl alcohol, but if a new use were discovered for this material the process would at once become of exceptional interest.

Among the names prominently associated with the synthetic or laboratory production of rubber Dr. Dannerth mentioned those of Perkin, Harries, Matthews, Hofmann, Strange, Coutelle and Fernbach. Many more could be added to this list, but these are the men who have done much of the fundamental work. Mention was made of the fact that if the United States were suddenly cut off from its rubber supply it would cost the American rubber industry over $250,000 per day. Speaking of the raw materials required, he stated that the Strange-Fernbach process required starch, and this could be economically obtained from potatoes. An annual production of 10,000,000 lb. of rubber might require 500,000,000 lb. of potatoes grown on 50,000 acres of land. The starch is converted by fermentation into acetone and butyl alcohol. Another process which has been suggested is based on the use of aldehydes and ethyl alcohol. Such a process would, if rational, make it possible to utilize our liquor distilleries in case of national prohibition. A process developed by the Badische Company is based on the use of acetone. This would be of very great interest to us, as we are in a good position to produce calcium carbide. A company has, in fact, just been formed for manufacturing this material in Virginia. The acetylene yields acetic acid and acetone. The acetone yields, on further treatment, pinacone, dipropylene, and dipropylene rubber. At the wholesale price of four cents per pound, calcium carbide is one of the most attractive raw materials at the disposal of chemical manufacturers for the synthetic production of rubber. This fact was emphasized very strongly by Dr. Dannerth, and he indicated that this was at the present time the one process which should be given serious consideration by American chemists and investors.

The financial prospects of synthetic rubber will depend upon such factors as: The demand for rubber in the United States; the price that could be obtained for the product; the minimum price at which natural rubber can be sold in the United States; the competition which would be experienced from the natural product; the factory cost of the product; the particular process which is chosen; the extent of side products and waste products; the operation of incidental processes; the possibility of irregularities in the process; the ability to secure college-trained chemists and engineers; the price of the raw materials; the abundance of the raw materials; the regular supply of the raw materials; the protective action of an import tariff on crude rubber; the efficient conduct of the processes; the cost of labor and the choice of correct machinery and apparatus.

Reference was made to the fact that, according to a published statement in 1905, the Hoechst and Badische companies sold indigotin to dealers in Germany at 18 cents per pound. The total world-production of rubber in 1916, figured on a "washed and dried" basis, was estimated at 427,250,000 lb. In the same year the U. S. Customs House reported the total importation of all kinds of rubber at 267,000,000 lb.

Benzol as a Motor Fuel.—J. H. CLEGG of the Blackburn, England, Gas Company, recently presented some interesting data before the Manchester Gas Association on benzol recovery. According to the *Gas Record*, Dec. 12, 1917, Mr. Clegg thinks there will be a big demand for benzol after the war. In this connection the following remarks by Mr. Clegg as to the English situation are interesting:

"I think that it behooves every gasworks to install a benzol plant, apart from patriotic reasons, as I venture to anticipate a great demand for this production as a power fuel, in spite of the fact that gas will undoubtedly retain the field which it is now obtaining as a propellant of motor vehicles. Even compressed gas in cylinders is scarcely adaptable or safe for motorcycles, of which there will be an enormous surplus at the conclusion of the war. Aeroplanes and airships will not by then be conveyances of the future, but will be well in evidence. Let us then aim to grasp the whole field of transport, either by gas, coke, or benzol. I have found by personal experience that benzol is more efficient than petrol, if the sulphur impurities are removed, and that the statement that the former coagulates the lubricating oil is not justified if a good quality oil is used. As for the cost of production, we know we can produce this commodity to compete favorably with petrol, for whatever the conditions existing for importation and distribution of the latter, like advantages or disadvantages apply to ourselves."

Recent Metallurgical and Chemical Patents

Coal-Tar Products

Production of Phenol.—HERBERT S. KIMBALL of Newton, Mass., patents a process of making phenol from benzol by a cyclical process. The patent is assigned to the Merrimac Chemical Co. of Boston, Mass. A complete cycle embodying the invention is shown on the accompanying diagram.

The present invention may be carried out as follows: The benzol is first sulphonated as usual, and the resulting sulphonic acid compound, containing an excess of sulphuric acid, is wholly or partly neutralized by calcium sulphite, utilizing for this purpose the calcium sulphite which is produced at a later stage of the cyclical process, as explained below. The neutralization is effected in closed tanks, and the evolved sulphur dioxide, or such portion thereof that may be required, is employed to decompose the sodium phenolate, as described in the above mentioned application. In case the quantity of calcium sulphite available is insufficient for complete neutralization of the sulphonic acid compound, it is supplemented by lime or limestone.

The calcium benzol sulphonate prepared as above is treated with the molecular equivalent of sodium sulphite, and is thereby transformed into sodium benzol sulphonate. The sodium sulphite may be introduced either in solution or in solid form into the solution of calcium benzol sulphonate, and the calcium sulphite which separates out is applied toward the neutralization of the sulphonic acid compound produced in the first step of the process.

The sodium benzol sulphonate is now subjected to a caustic fusion to produce sodium phenolate, which in turn is decomposed by sulphur dioxide (undiluted) arising from the neutralization step of the process. The phenol is decanted, and the remaining liquor, containing sodium sulphite or bisulphite, or a mixture of these, is utilized in part for the conversion of the calcium benzol sulphonate into the corresponding sodium salt, as above described, and is in part causticized by lime, yielding a dilute caustic soda solution and calcium sulphite, the latter available for neutralizing the benzol sulphonic acid. If desired, the caustic soda solution may be concentrated and returned to the cycle. (1,245,353, Nov. 6, 1917.)

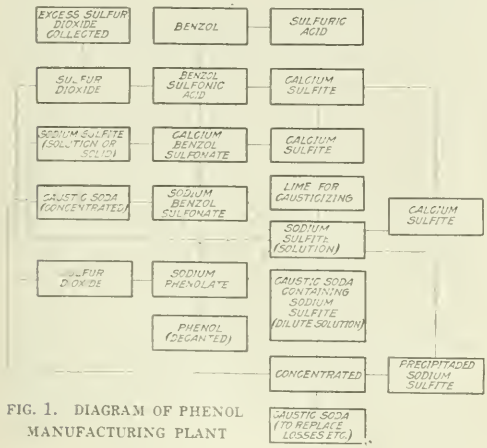


FIG. 1. DIAGRAM OF PHENOL MANUFACTURING PLANT

Production of Phenol.—In a patent granted to HENRY HOWARD of Brookline, Mass., the sodium phenolate prepared as usual by the caustic fusion of the sulphonic body, is decomposed by sodium bicarbonate, preferably employed in the proportions required to transform all of the sodium, whether present as phenolate or as caustic soda associated with the phenolate, into normal sodium carbonate. Under these conditions the reaction is stated to be very rapid, and even practically instantaneous. The reaction will proceed at normal and higher temperatures, and is exothermic; 60 deg. C. is a satisfactory operating temperature, although either higher or lower temperatures may be used. There are no fixed upper or lower limits for the concentration of the phenolate solution, but a concentration in the neighborhood of 23 deg. Baumé is satisfactory in practice. To avoid unnecessary dilution, the bicarbonate may be added to such solutions in solid form, although this is not essential. Most of the phenol rises to the surface of the liquid, and may be separated by decantation, the remainder being recovered from the carbonate solution in any appropriate way, as, for instance, by distillation, or by blowing steam through the liquid. About one-half, or somewhat less, of the sodium carbonate solution produced as above, is now treated in any suitable apparatus with the lime-kiln gas, and is thereby reconverted into sodium bicarbonate, which is used for the treatment of another batch of sodium phenolate. The remainder of the sodium carbonate solution is causticized by lime, and may be concentrated for re-use in the preparation of the phenolate, or applied to any other purpose. (1,245,343, Nov. 6, 1917.)

Miscellaneous Chemical Processes

Paraffin Ethers.—The manufacture of paraffin ethers such as ethyl ether is the subject of a patent of BURRITT S. LACY of Sewaren, N. J., assigned to the Roessler & Hasslacher Chemical Co. of New York. The following reactions illustrate the manufacture of ethyl ether:

$$(1)\quad C_2H_6 + Cl_2 = C_2H_5Cl + HCl$$
$$(2)\quad 2C_2H_5Cl + CaO = (C_2H_5)_2O + CaCl_2$$

It was found that under certain conditions the formation of ethers as exemplified by reaction (2) may be sucessfully carried out and with nearly quantitative yields. In connection with this fact it was found especially in working on a large scale, that the highly exothermic character of reaction (2) presents a serious difficulty due to the tendency to rapid decomposition and carbonization brought about by the heat of reaction itself. It was furthermore found, however, that this unfavorable heat evolution may be wholly neutralized and the reaction made entirely successful even on a large scale by means of admixture with the ethyl chloride of a large amount of an inert gas.

Any one of a number of inert gases, for example nitrogen or methane may be employed, but it is preferable to use the excess C_2H_6, which is already present with the C_2H_5Cl when prepared according to reaction (1) as described in copending application Serial No. 852,164 filed July 21, 1914, for the manufacture of ethyl

chloride since the process then becomes a continuous cycle with production of substantially only HCl, ethyl ether, and $CaCl_2$, without the necessity of first separating the C_2H_5Cl as such.—(1,245,742, Nov. 6, 1917.)

Salt Cake and Nitre Cake in Making Silicofluoride.—KARL F. STAHL, of Pittsburgh, Pa., patents a process of treating phosphate rock for the production of sodium silicofluoride from the fluorine and silicic acid contained. Phosphate rock contains some flourine as calcium fluoride and silicic acid either free as silica, or combined as silicates. In the process of making acid phosphate for use as a fertilizer the ground phosphate rock is mixed with sulphuric acid which has previously been diluted to the required strength. This converts the tertiary calcium phosphate into primary phosphate, rendering it soluble in water, but it also liberates the flourine of the calcium fluoride, forming hydrofluoric acid. This acid in turn combines with the silica forming principally silicon fluoride (SiF_4), which, as a gas, escapes into the air and is detrimental to surrounding property. In order to prevent the escape of this gas, the silicon fluoride is brought into contact, in suitable apparatus, with sprays of water, and this decomposes the silicon fluoride into hydrofluosilicic acid and silicic acid according to the equation:

$$3SiF_4+3H_2O=2H_2SiF_6+H_2SiO_3$$

The hydrofluosilicic acid is immediately absorbed in the water in which the silicic acid remains suspended. The two are separated by means of a filter press and the hydrofluosilicic acid is converted into sodium silicofluoride, a useful product, by means of a solution of sodium chloride, according to the equation:

$$H_2SiF_6+2NaCl=Na_2SiF_6+2HCl.$$

This leaves a weak solution of hydrochloric acid which is of little value and cannot be utilized in the process. In locations where there is no large body of water it is necessary to make some arrangements for the disposal of this weak solution of hydrochloric acid which is produced in considerable quantity. This problem becomes very difficult in some cases and practically prohibits the erection of a plant for the production of sodium silicofluoride where such plant would otherwise be most favorably situated.

One of the objects of the present invention is to provide an improved process for treating phosphate rock in which resulting products of value or ones which may be easily disposed of are produced. Another object is to provide an improved process for treating phosphate rock in which the product resulting from the conversion of hydrofluosilicic acid into sodium silicofluoride may be utilized in the process of treating the rock.

The phosphate rock, according to the improved process, is treated with sulphuric acid which renders the phosphate soluble in water and produces hydrofluoric acid. This acid combines with the silica, forming principally silicon fluoride (SiF_4), which afterward is decomposed into silicic acid and hydrofluosilicic acid and this latter acid is then absorbed in water. Instead of treating this solution with sodium chloride, it is treated with a solution of sodium sulphate which precipitates sodium silicofluoride according to the following equation:

$$H_2SiF_6+Na_2SO_4=Na_2SiF_6+H_2SO_4$$

The sodium silicofluoride is sparsely soluble in water or in dilute sulphuric acid, and consequently is thrown down as a fine powder or sludge, which is separated from the liquid by a suitable filtering device, such as a filter press or centrifugal machine. It is then washed free of acid, dried and ground, whereupon it is ready for shipment.

The dilute sulphuric acid which is produced by this reaction may be utilized in the process of treating the phosphate rock so that no provision need be made for the disposition of large quantities of waste acid liquid. For the purpose of acidulating the phosphate rock in the initial reaction sulphuric acid of 50 deg. Baumé, is generally used. In the usual chamber process of making sulphuric acid the latter is usually produced stronger than 50 deg. Baumé and to use it for acidulating phosphate rock it is diluted with water to reduce its strength. In the present process, instead of diluting this acid with water, it is diluted with the sulphuric acid solution obtained in the final stage of the process. Such solution generally contains sulphuric acid in a dilute state of about 7 deg. Baumé. The acid solution resulting from the process is thus not only disposed of but it is utilized in the treatment of the phosphate rock. Sodium sulphate and acid sulphate may be obtained in the form of salt cake and nitre cake respectively, which are waste products from the manufacture of hydrochloric and nitric acid. They are relatively inexpensive and often contain some free sulphuric acid. In such case more sulphuric acid or a stronger acid is obtained in the final stage of the process which may be used in treating the rock. The process thus enables the waste cake from the nitric or hydrochloric acid process to be used. In addition to disposing of the waste products from these acid processes, the use of such products in treating phosphate rock produces a resulting acid solution which may be again used in the initial step of treating the rock. The waste products of two processes are thus saved and the difficulty of disposing of them avoided. The sulphuric acid does not affect the apparatus for handling the precipitated sodium silicofluoride to as great an extent as the hydrochloric acid heretofore produced and therefore it is claimed renders the process more inexpensive by reason of the reduction in the replacements of apparatus. (1,247,165, Nov. 20, 1917.)

Acetaldehyde from Acetylene.—It is well known that acetylene may be caused to unite with the elements of water, yielding acetaldehyde, by bringing it into contact with a suitable compound of mercury in the presence of sulphuric acid. HAROLD HIBBERT of Pittsburgh, Pa., patents an improvement on processes of this general character and assigns same to the Union Carbide Co., of New York City.

According to the invention, acetylene is led into an acid bath of the general character above mentioned, in material excess of the amount which can be absorbed in the first reaction. The bath is preferably maintained at a temperature of 70 deg.—80 deg. C., whereby the bulk of the acetaldehyde formed is continuously distilled off, mixed with the excess of acetylene. These mixed gases are conveyed directly to a second acid bath, preferably having the same characteristics as the first, where a further reaction takes place. If desired, the commingled gases from this second bath, which by

reason of the further reaction will contain a proportionately smaller amount of acetylene, may be conveyed to a third bath, and so on to any desired number of series-connected baths. Ultimately a sufficiently complete absorption of acetylene, for example an absorption in excess of 75 per cent of the original volume, is secured. The exit gases from the final bath, consisting predominantly or substantially of acetaldehyde, are led to a condensing system, from which any residual acetylene may be returned to the first element of the absorption system, together with sufficient added acetylene to re-establish the desired excess. The rate of supply of acetylene to the system will depend upon several factors, including the number of vessels in series, the volume of the acid baths, and their conversion efficiency. Usually it is preferred to supply acetylene at such rate that some 50 per cent, more or less, of the gas entering the first absorption vessel will pass therefrom to the next in series. (1,247,270, Nov. 20, 1917.)

Iron and Steel

Sintering Ores.—A continuous sintering process for sintering fine ores, concentrates, etc., is patented by JAMES GAYLEY of New York City. The apparatus can be applied to lean magnetic ores containing from 30 to 40 per cent of iron and which are too fine for direct use when concentrated. Large scale operations are necessary in order to be profitable. One of the features of the present process is the possibility of treating layers several feet thick, whereas formerly only about 7 in. thickness could be treated on a continuous machine. The sides of the cars may be of any height desired and the number of idle cars is greatly reduced. In general the process consists in the employment of two parallel tracks, in substantially the same horizontal plane, over which the cars are adapted to be moved uniformly and continuously in reverse directions. Having reached the discharge end of a track each car is emptied of its sintered contents, transferred in any suitable manner to the return track, refilled with ore or other material, which is then ignited and sintered during the passage of the car to its original starting point, where it is again dumped, refilled and caused to travel in the reverse direction over the first track. Some of the advantages of the process as given in the patent specification are as follows:

"By far the largest proportion of materials which are sintered at the present time by the continuous process, rarely require for the best operative results a depth or layer in excess of 9 in., consequently, the sides of the cars or pallets are made low, and they *have no upright ends at all.* The cars are also carried on wheels that run on the tracks provided for that purpose, and at both ends they are so constructed or planed off that they will make tight joints when brought together in a train to prevent the leakage of air. It is further usual to provide on the sides of the cars wind seals, preferably composed of single bars free to move vertically in a slot in the car body and slide over the edges of the wind box. In the process of sintering herein described the cars are always held in an upright position, so that this or many other forms of wind seal may easily be applied and used.

"The advantage of using cars without upright ends follows from the fact that this provides for the operation being carried on as a strictly continuous one. The several cars are dependent in the sense that their ends contact to make close air-tight joints throughout the sintering train. The layer of sintering material which such cars support is, moreover, continuous, or uninterrupted throughout the sintering period. From this it results that the ignition of the layer is more uniformly and effectively performed, and carried out while the cars are in motion. When independent cars with side and end walls are used the ignition of the charge takes place under a hood, the cars having the side and end walls of equal height to prevent leakage of the ignition flame, and it is required that each car remain stationary while the ignition of its charge is taking place.

"These stoppages of each car, in turn, stop the whole train and thereby render the process an intermittent one, curtailing the sintered output and imposing a variable load upon the suction fans through the variations in the percentage of the total sintering bed from time to time, thus producing at different times a variable suction pressure in different parts of the same, but disconnected sintering bed.

"The material which lies against the sides and ends of independent cars is, moreover, not so perfectly ignited, so that the elimination of ends reduces the area of imperfect ignition. Besides, the car with side and end walls makes the sintering layer disconnected, and it is not practicable to properly ignite a moving layer which may vary considerably in depth. For effective and economical ignition, the igniter must be close to the moving layer to produce the required heat concentration, but if for any reason a change occurs in the character of the material to be sintered, and a varying depth of the layer is required, it is not possible with independent cars to properly adjust the height of the igniter above the layer, as this is limited by the ends of the cars which must pass under the igniter, and in consequence the ignition and sintering of the layer is imperfect.

"In treating the same kind of material in a connected or continuous layer, the igniter can be placed in a fixed and proper position for that material and remain in such position, and this fact permits the use of a gas of low calorific power such as blast furnace gas, while intermittent ignition under a hood requires a high calorific and much more expensive gas.

"In sintering operations where independent cars are used and the charges ignited under a hood, the charging of the cars and the ignition of the material become manual and intermittent operations, whereas in the method or process as herein described, the only manual operations involved are the dumping and the transferring of the cars." (1,247,661 Nov. 27, 1917.)

Dolomite Refractory Brick.—JAMES O. HANDY and ROBERT M. ISHAM of Pittsburgh, Pa., patented a dolomite refractory brick and process of making same. The patent is assigned to the Allen S. Davison Company of Pittsburgh, Pa. In granulating calcined dolomite for making refractories for basic open hearth furnaces, considerable dust and fine material are produced. In the present patent it is proposed to use this dust for producing refractories, either alone or in mixture with other material. This waste dolomite is dead burned as it comes, and is afterward submitted to a brick-making treatment and another dead burning, producing strong, dense and refractory bricks. It is stated that they show no tendency to slack when placed in boiling water. For burning it is a matter of convenience to add more or less water to the dust to ball it up and form aggregates which can be handled in a rotary kiln; a rotary kiln being well adapted for this first burning. No other treatment is necessary. (1,248,486, Dec. 4, 1917.)

Rust-Proofing Iron and Steel.—A process of rust-proofing using vapors containing phosphorus compounds is patented by WILLIAM H. ALLEN of Detroit, Mich. The process consists in subjecting articles of iron and steel, properly cleaned by pickling or sand blast, to the fumes or vapors of phosphorus pentoxide or anhydride together with some aqueous vapor until surfaces of basic phosphates of iron are produced. These vapors may be produced in any desired manner, the preferred process consisting in subjecting a mixture of ground phosphate rock, coke and sand to a strong current in an electric furnace. The liberated phosphorus immediately changes to P_2O_5, and these fumes are drawn into the processing chamber by means of a suction fan. The fumes may be first passed through a dust chamber. (1,248,053, Nov. 27, 1917.)

Temperature Regulator.—PORTER H. BRACE of Pittsburgh, Pa., patents a regulating device which is particularly applicable to the regulation of heat treating, motor speeds, pressure in tanks, etc. The patent is assigned to the Westinghouse Electric & Manufacturing Company. The apparatus includes a potentiometer conductor, a thermo-couple or generator that is subjected to the temperature of the device, the temperature of which is to be regulated or that is actuated in accordance with other varying conditions, such as speed, pressure or energy, and a galvanometer for controlling the operation of a potential regulator or other regulating device. The galvanometer is connected in series with the thermo-couple or generator, and the circuit, thus constituted, is connected to the potentiometer conductor. A periodically actuated cam device having a contour corresponding to the desired time-temperature or other predetermined curve is adapted to so change the connections of the series-connected circuit, with respect to the potentiometer conductor, that the galvanometer is adapted to control the potential regulator or other regulating device to cause the temperature, pressure, speed or energy to vary in accordance with the predetermined desired characteristics. (1,248,444, Dec. 4, 1917.)

New Holder for Drawings and Blue Prints

The accompanying photographs show a new holder for drawings, blue prints, specifications, etc., made by the National Company, 273 Congress Street, Boston, Mass. Fig. 1 shows the lock which is used for

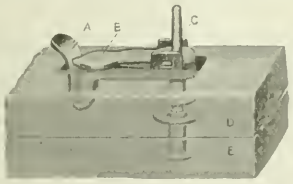


FIG. 1

holding the sheets and Fig. 2 shows the top string of the binder removed and print being taken from or added to file as desired. Referring to Fig. 1, the binder is locked by pressing on A. To release the

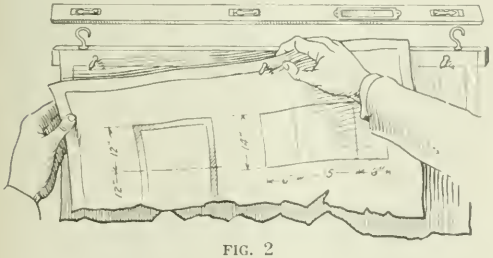


FIG. 2

binder the tongue B is pressed. This locks or releases B on hardened stud C, which is fastened into lower strip of oak-wood binder E.

The holder has a removable index card and will hold from one to sixty prints, without tearing or soiling.

Improved Quartz Mercury-Vapor Lamp for Ultra-Violet Light

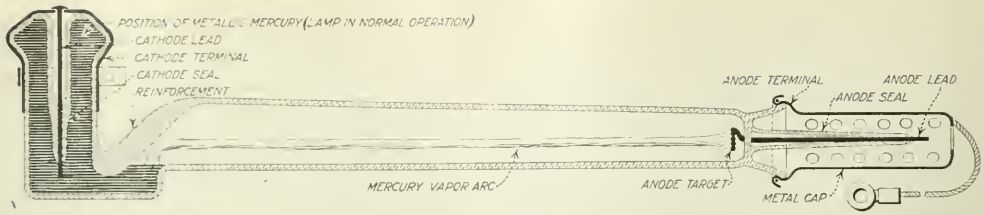
THE photochemical activity of invisible light waves existing beyond the visible violet of the spectrum has long been a recognized fact, and considerable research has been done to determine the nature and extent of the reactions produced. The shortest wave length of light perceptible to the eye is about .3969μ, in the violet end of the spectrum. Rays of shorter wave-length vary in their activity and effect. Berthelot divided them into four groups: 1. Wave lengths 0.4 to 0.3μ, comprising the ultra-violet rays that reach the earth's surface in sunlight. These rays are similar to the violet rays of the visible spectrum. 2. Wave lengths 0.3 to 0.2μ, medium rays of strong photochemical effect, producing marked chemical and physical changes. 3. Wave lengths 0.2 to 0.15μ, useful in synthetic processes. 4. Wave lengths 0.15 to 0.1μ, comprising an ultra-violet region about which little is known.

Among the physical and chemical effects produced by ultra-violet light are many of practical value, affording quick tests for certain properties, and acceleration of certain chemical reactions. The sterilization of liquids such as water and milk, and of semi-solids like edible fats, is readily accomplished by ultra-violet rays. Exposure of only a fraction of a second under proper conditions is required for complete sterilization. Most dyes fade rapidly under treatment with ultra-violet light, and some remain fast. Fabrics like cotton, rubber, oil-cloth, etc., reveal in a comparatively few minutes the deterioration that otherwise would not become apparent for days in ordinary light. Numerous organic substances are bleached by its action.

Chemical reactions produced by ultra-violet light are many and varied. Chlorine derivatives of toluol are produced in greatly increased yields and without undesirable by-products if the reaction proceeds in the presence of ultra-violet rays. Other chlor-substitution organic products are formed with greater facility, in greater quantity and of higher degree of purity if ultra-violet light enters into the reaction. The halogen elements generally seem sensitive to this force and enter into synthetic reactions rapidly under its influence. Cyanogen is converted into para-cyanogen, sulphur and phosphorus show allotropism, organic compounds undergo isomeric changes, hydrolytic reactions are accelerated, and numerous other changes occur under influence of ultra-violet rays.

The production of these rays in a manner suitable for application in the arts has been the subject of considerable invention. They are given off in concentrated form from a mercury-vapor lamp, but since glass is impervious to them it is necessary to construct the lamp of quartz if the rays are to be used.

An improved form of quartz mercury-vapor lamp which embodies new features in construction and application is manufactured by the R. U. V. Company, New York City. This lamp produces an ultra-violet component several times stronger than that yielded by other forms of quartz mercury-vapor lamps. The wave lengths of its light have been measured as low as 0.18μ, indicating a high degree of activity according to Berthelot's classification given above.



IMPROVED LAMP FOR ULTRA-VIOLET RAYS

The shape of the lamp is shown in the accompanying drawing. It consists principally of an exceptionally clear crystal-quartz frame containing mercury, fitted at each end with terminals and provided with an unusually high vacuum. The cathode terminal of the lamp under running conditions contains practically all of the mercury, as the pressure built up in the luminous tube forces the mercury back into the cathode end. The anode end is fitted with a tungsten terminal that is refined to a point approaching 100 per cent purity in order to prevent discoloration of the luminous tube.

The seals consist of tungsten wire sealed to the tube by means of a graduated mixture of glass and quartz, so distributed as to present approximately 100 per cent quartz nearest to the luminous tube and 100 per cent glass at the outside end of the seal. This combination of glass and quartz provides proper coefficient of expansion to prevent loss of vacuum.

The luminous tube or that part of the lamp in which ultra-violet rays are radiated, extends from the reinforcement bend near the cathode end to the tungsten coil forming the anode terminal, and therefore presents a radiating distance approximately 6 in. long.

This type of lamp is known as the "hot anode" type and differs from all other designs in that no mercury chamber is used at the anode end. This feature permits of operation of the lamp in any plane from vertical to horizontal, and therefore permits of application to practically any form of equipment used by the chemical manufacturer.

The metal cap fastened to the anode end, and attached directly to a collar at the end of the luminous tube, prevents the anode seal from mechanical injury and provides as well a means for attaching the positive lead wire in such a way as to remove strain from the anode seal. The negative seal is protected from strain by soldering it with silver to a strap which passes over the top of the cathode end. It is held rigidly in place by a circular band fastened around the vertical bulb of the cathode end.

The cathode end of the luminous tube is reinforced with thick quartz to absorb the shock of the mercury-vapor arc which strikes against it, while the other end of the mercury-vapor arc terminates against the target formed by the coil of tungsten wire which is the anode terminal. It is considered that the angle presented by the reinforcement of the luminous tube to the mercury-vapor arc, is such as to reflect back into the luminous tube some ultra-violet light that otherwise would escape.

To start the lamp the luminous tube is placed in a horizontal plane which permits the flow of mercury across it, so connecting the anode and cathode terminals, and immediately after the current is supplied to the lamp the anode terminal is tilted upward to strike or draw an arc. In a short time thereafter sufficient temperature and pressure is built up inside the luminous tube to produce the maximum amount of ultra-violet of which the lamp is capable.

To support this mercury-vapor arc, as in the case of all mercury-vapor arcs, ballast resistance is required, and such resistance is placed in series. When the lamp is started cold, about 20 ohms resistance is placed in series, but when the lamp is normally operating, one-half of this resistance is cut out so that normally 10 ohms is constantly in series with the lamp terminals. This cutting out of resistance is accomplished automatically on a small switchboard that is provided as an accessory to the lamp.

The starting characteristics of the lamp are therefore 8.5 amp. at 220 volts D.C., which is required normally for 10 to 15 min. As soon as the starting resistance of 10 ohms is cut out, the lamp, then being in normal running condition, consumes 3.5 amp. at 220 volts D.C.

Insulation Test on Steam Drums

An interesting test for determining loss of heat by radiation from boiler settings and steam drums was recently made by Mr. C. A. Eastwood, Superintendent of Station A, Pacific Gas and Electric Company, San Francisco, Cal. For his experiment Mr. Eastwood selected a 560-h.p. B. & W. boiler, the steam drums of which were covered with one course of common brick. A rectangular can containing a measured quantity of water was placed on top of one drum and the boiler was run at its rated capacity for a period of three days. During this time the rise in temperature of the water was carefully noted, and with these data it was a comparatively simple matter to determine: (a) the amount of heat radiated per square foot of surface per hour; (b) the amount of heat radiated from the total exposed area of the drums, and (c) the quantity of fuel which was being burned to make up for this loss. Mr. Eastwood's figures showed that the loss totaled 390 barrels of oil per year.

To determine how much of this fuel-loss could be saved by the use of an effective heat insulating material, one 2½-in. course of nonpareil insulating brick (Armstrong Cork & Insulation Company, Pittsburgh, Pa.) was then placed on top of the common brick covering, and readings were taken as in preceding tests. The result showed that with the nonpareil brick in place the loss of heat amounted to only 144 barrels of oil per year. With oil costing 70 cents per barrel, the saving amounted to more than enough to pay for the cost of the insulating brick and the labor required for installing them.

The total amount of heat lost represents that radiated from the steam drums alone. Had the radiation from the exposed boiler walls been included as well, the total heat-loss would have been greatly increased. Furthermore, if the common brick had been removed entirely and replaced with a coarse nonpareil brick set on edge, giving 4½ in. of insulation instead of 2½ in., a still greater saving would have been effected, since, according to the manufacturers, nonpareil brick are ten times better heat insulators than either common brick or fire brick.

Personal

MR. L. DOUGLAS ANDERSON, superintendent of the Midvale, Utah, smeltery of the United States Smelting Co., has been appointed manager of smelteries for the company at Salt Lake City, Utah. The company is a subsidiary of the United States Smelting, Refining and Mining Company.

MR. H. A. BAKER, chief chemist of the American Can Co., has gone to Washington to act on the committee on conservation of tin plate.

Professor CHARLES BASKERVILLE, Professor of Chemistry and Director of Laboratories of the College of the City of New York, delivered a lecture at the Royal Canadian Institute, Toronto, Canada, December 8th, the subject being, The Hydrogenation of Vegetable Oils.

MR. WARREN F. BLEECKER, of Boulder, Colo., spent a few days in New York during Christmas week.

MR. C. L. BRICKMAN was recently appointed chief chemist by the Rex-Hide Rubber Manufacturing Company, East Brady, Pennsylvania. Mr. Brickman comes from the Research and Development Laboratories of the U. S. Rubber Company.

Mr. E. J. CARLYLE and Mr. M. R. HULL have recently returned from Russia. Mr. Carlyle is manager and Mr. Hull, engineer, of the Sissert Mining Company, which operates a large concession in the Ural Mountains, near Ekaterinberg, mining and smelting copper ores. While the property was still operating at the time of their departure, the management had been assumed by committees of workmen, in accordance with their ideas of freedom. Messrs. Carlyle and Hull expect to make Salt Lake City their headquarters for some time.

Mr. A. E. DRUCKER is in Baltimore supervising the construction and starting of a concentrator mill.

Mr. ALFRED D. FLINN, deputy engineer of the Board of Water Supply, New York City, has been elected secretary of the Engineering Council, secretary of the Engineering Foundation, and secretary of the United Engineering Society. The Engineering Council was formed early in the fall of 1917, and its organization was described in our issue of Sept. 15, 1917. The United Engineering Society is the governing board of the Engineering Societies Building into which the Civil Engineers recently moved, and the Engineering Foundation is the founder organization of the societies which originally combined into the one organization. Thus all these activities will center in one man.

Mr. L. F. S. HOLLAND, lately field engineer for the Consolidated Arizona Smelting Co., Humboldt, has been appointed consulting engineer to the Arizona Mines & Reduction Co., Wickenburg, Arizona.

Mr. D. C. JACKLING, of San Francisco, has been placed in charge of building the Government's explosive plants. He will act under authority of the Secretary of War, by whom he was appointed. There is contemplated the expenditure of more than $90,000,000 in the erection of explosive plants for the Government, in order to supplement the present output of private manufacturers which it is calculated will not be sufficient to meet the Government's future needs.

Mr. E. F. LAKE, metallurgical engineer, formerly located in Detroit, Mich., has taken the position of assistant superintendent of the Rich Tool Co. The company is manufacturing one-piece valves from high-speed steel for airplane and automobile engines. It is also making valves from a high chromium steel similar to the stainless steel recently placed on the market.

Mr. R. A. LEAHY, formerly on the research staff of the Anaconda Copper Mining Co., has joined the Royal Flying Corps, and is now at Toronto, Ontario, Canada.

Dr. GILBERT N. LEWIS, of the University of California, has recently received a commission as major in the gas service. He will go abroad.

The Hon. SIR CHARLES PARSONS, member of the Council of the Institute of Metals (London), is to give the eighth annual May lecture before the Institute of Metals next spring. The lecturer will deal with the subject of the formation of artificial diamonds, which he has been experimenting upon for over thirty years.

Mr. ROBERT K. TOMLIN, JR., managing editor of *Engineering News-Record*, sailed recently for France to serve *Engineering News-Record* and the other McGraw-Hill engineering publications as special correspondent at the front.

Prof. WM. H. WALKER, head of the chemical engineering department of Massachusetts Institute of Technology has been commissioned lieutenant-colonel in the Chemical Corps, U. S. A., a newly created branch of the war department. He will have charge of co-ordinating the chemical activity in this country while Dr. Raymond F. Bacon, of Mellon Institute, Pittsburgh, will be engaged in the same capacity in France.

Obituary

DR. HUGO SCHWEITZER, the well known chemist and dye expert, passed away Dec. 23, at his home 410 Riverside Drive, New York City. He was head of the Synthetic Patents Co., 117 Hudson Street, New York City, and had a long experience in dyestuffs and organic chemistry. He was born in Germany in 1861 and received his degree at the University of Freiburg. He was successively chemist for the Badische Anilin and Soda Fabrik, Ludwigshafen, and the Farbenfabriken, formerly Fr. Bayer Co., Elberfeld. After he came to this country he became an American citizen and was past secretary of the New York Section of the Society of Chemical Industry and ex-president of the Chemists' Club.

Book Reviews

PRACTICAL PYROMETRY. By *E. S. Ferry, G. A. Shook* and *J. R. Collins*. Duodecima (14 x 20 cm.), 147 pages, 73 illustrations. Price, $1.50. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd.

An elaboration of notes compiled for a student laboratory course in Purdue University. After a short introductory chapter on temperature scales, the other four chapters deal with resistance, thermoelectric, radiation and optical pyrometry respectively. These are well presented, with many good experiments to teach the basic principles on which they act. Other forms of pyrometry than these four are *practical*, however, and are not considered. The book is to this extent defective. The English is poor at places, and scientific terms carelessly or inaccurately used at times. We cannot agree with the statement that iron, steel and nickel become brittle at about 700 deg. C. (p. 27). The book is pretty good, with some weak features, like those noted.

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METALLURGICAL CALCULATIONS. Part I: Chemical and Thermal Principles. By *J. W. Richards*. Fourth Edition, revised and enlarged. Octavo, 238 pages. Price, $2.00. New York: McGraw-Hill Book Company. London: Hill Publishing Co., Ltd.

Since the first edition of this work was published, in 1906, it has become so widely used and known that further cataloging of its contents is unnecessary excepting a notation of the improvements in this last edition. The valuable thermo-

chemical tables have been brought up to date, and arranged in a better form; the tables of thermophysics of the elements have been greatly extended, to include heats of fusion and vaporization and vapor tensions of the elements; the thermophysics of chemical compounds have been amplified; the table of thermal emissivity has been lengthened by recently determined data. This fourth edition should therefore be much more valuable to the metallurgist and engineer than the preceding editions. By an unfortunate error (page 100), the total heat in mercury at its boiling point is given as 117 instead of 11.7, which changes the heat in the vapor at the boiling point to 79.5 and at the critical point to 100.

The publishers inform us that they contemplate issuing a one-volume edition of all three parts of Dr. Richards' work. It may not be generally known that these calculations have been translated into Russian, Italian and German, and that translations into French and Spanish were begun, but have been interrupted by the war. This is an enviable record of the general appreciation of these books by technologists in all parts of the world.

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EVERYMAN'S CHEMISTRY. By *Ellwood Hendrick.* Octavo, 374 pages. Price, $2 net. New York: Harper and Brothers.

This is a book in which the author sits down with you and converses delightfully on the "ways of stuff," in an effort to convey to the average man a sense of the importance of chemistry in modern life. If he catches your interest lagging or your eye wandering, he promptly recovers your attention by opening a new view of the subject. Those who have thought of chemistry as though it were spelled "chemystery" will find here an easy comprehension of the elements of the subject that will lead them on to deeper study. Being a man of imagination, the author resorts to many forms of imagery in order to convey his subject clearly and interestingly to the reader. He frequently resorts to analogy between the "ways of stuff" and the characteristics of people to show why materials act as they do. Thus, among the "red-headed halogens" we find fluorine to be a "young devil" and iodine an "old man with a past." Allotropy is explained as a sort of "Dr. Jekyll and Mr. Hyde" state of matter. The stories of the elements and their compounds are enlivened by up-to-date examples of chemical application in the arts. In this way the author brings in the Cottrell process, permutit, fixation of nitrogen, and the simple metallurgy and uses of the metals. War time is reflected in the mention of war uses for chemicals, notably explosives. All the romantic interest attaching to the chemistry of carbon compounds is brought before the reader in as much detail as the scope of the book will permit. The wide distribution of the book will make for an enlightened public intelligence on the great chemical industry which is bound to grow in importance in this country.

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LABORATORY GUIDE OF INDUSTRIAL CHEMISTRY. By *Allen Rogers.* 212 pages, illustrated. Price, $2.00 New York: D. Van Nostrand Co.

A laboratory manual of Industrial Chemistry prefaced by a brief description of the more common forms of industrial chemical apparatus. Then follows a series of experiments in inorganic preparations, the raw materials being used in about one kilo lots. Typical preparations described are magnesium sulphate, potassium permanganate, sodium thiosulphate, sulphur monochloride, etc. A chapter is devoted to organic preparations corresponding to those usually given in a beginning university course in this subject.

The main part of the manual is devoted to well-chosen experiments in the dyeing of textile fibers, pigments and lakes, driers, varnishes, paints and stains, soaps and allied products, leather manufacture and wood fiber and paper. In each case the detailed experiments are preceded by a concise statement of the main principles involved. The experiments aer representative and reflect factory operations, and should be of great value to the student, especially when they are carried out under the foremanship system as at Pratt Institute, where "groups of students are assigned to work in model plants, one member of each group acting as foreman. The foreman is held responsible for the quality as well as the quantity of the output of his plant, must see that the machinery is left in perfect condition, and that the factory is kept clean." Few schools could carry this method out, which ought to give good results, but the text should be a workable one, even with less equipment than the foreman method involves.

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A PRACTICE BOOK IN ELEMENTARY METALLURGY. By *E. E. Thum, E. M.* Octavo (15 x 23 cm.), 321 pages, 57 illustrations. Price, $2.75. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd.

The author was assistant professor of metallurgy at the University of Cincinnati, and prepared this book for the use of his students, who, according to the system there in vogue, come to the university in alternate two-week periods, spending the other periods in shops or works. The limited time allowed for lectures gave little opportunity for discussing with the students the principles underlying the experiments, so it was decided to write a laboratory manual for them and print the explanations therein. The subjects covered by the experiments are well chosen, and students carrying them through and studying the text cannot fail to learn some good metallurgy. On the other hand, the details are so closely connected with the local conditions and limitations under which the author labored that the general usefulness of the book is greatly impaired thereby. It may be a very useful handbook at the University of Cincinnati, and it might be of very little use in some other institutions differently situated, with different equipment, and with students working on a different plan of instruction. It is, however, full of good suggestions for anyone planning metallurgical laboratory work.

The Chemical Market in the United States in 1917

Coal Tar Products

During the past year additional strides were made in the production of coal tars and intermediates; in fact, this branch of the chemical industry continued to hold out the most glowing prospects in the way of a quick return on the money invested, which, of course, is always the primary consideration in the establishment of a new industry, inasmuch as it is then possible to secure sufficient financial backing to carry forward the perfection and completion of experiments with the proper degree of assurance. While the years 1915 and 1916 saw considerable in the way of improvements, not only in production, but also in the quality of the products, the year just passed has eclipsed the records of these years to such an extent that they seem to be mere memories, as we review the happenings' in 1917. At the close of 1916 practically all the intermediates were being produced, with the exception of a few, which were more difficult to produce and bring to a state of perfection. But during 1917 ideas were developed in a slow, painstaking manner and concentration was more generally adhered to in an endeavor to overcome the temerity of consumers of American products, who had been disappointed when they found that these products could not be used to the same advantage as the foreign products to which they had been accustomed. With renewed application some of the larger producers succeeded in overcoming the prejudice thus engendered by the production and perfection of high-grade products, with the result that as the year ends there is practically nothing that Germany produced that we have not been able to master.

For a time the pioneers in the field of production in specialties waxed fat on the new industry. But the way of the world was not different in this case than others, and as soon as it became apparent that this new field offered such wonderful opportunities, many new companies entered into the line, with the result that at the end of the year only a few of these concerns were able to weather the sea of competition, with its slashes in prices and general undermining of the industry, and the year ends with only the stronger factors surviving and prices on a lower parity. The tendency in general is rather to build up a regular trade by the pro-

duction of a standard product at a good though not unreasonably large profit. With this object in view, many firms have established for themselves a name that is synonymous with quality and their success is encouraging.

As the year draws to a close several producers of the intermediates have curtailed and some have closed down owing to governmental seizure of toluol and phenol, except when used in the fulfillment of requirements for the government. But it is the general impression that the authorities at Washington will shortly arrange matters so that the industry will not be destroyed. Release of material to consumers is expected shortly, through the medium of committees.

The industry on the whole has not been affected by the entry of this country into the war.

Coal Tar Crudes

Production figures of benzol are not available, but greater quantities were produced this year than last year, and authorities believe that the total will be several million gallons over last year's estimated total of 30,000,000 gal. There were 70 concerns with benzol recovery apparatus as against 61 in 1916. While the output in 1916 was fairly well absorbed, the quantities produced in 1917 were greatly in excess of the demand, as there was considerable falling off in export requirements, with the result that prices have been tumbling for the past few months and apparently have not yet reached the bottom. Benzol on spot can be done now at 36c. to 40c., according to quantity and buyer and seller, as against 75c. to 60c. in 1916, and 77c. to 80c. in 1915. Contract business over 1918 is being done at 36c. to 42c. for the pure material. The 90 per cent grade is not produced in such great quantities and a higher price obtains for this material than for the pure, but some rubber manufacturers apparently prefer this grade.

Toluol.—During the year prices did not vary greatly from those prevailing at the close of 1916. For the most part $1.50 to $2.00 covered the range. However, in November the government requisitioned the entire production for use in the manufacturing of explosives, and such quantities as were in dealers' hands have since sold at fancy figures. As high as $3.50 a gallon has been paid for small quantities. Producers of intermediates to be used as dye bases, or in other necessities, have been favored with releases of moderate amounts, but they are for the most part operating on a hand-to-mouth basis. It is probable, however, that a committee will be appointed to handle in a business-like way the matter of releases. The 1917 production was much greater than the 8,000,000 gal. produced in 1916, but accurate production figures are not available.

Xylol.—The production was greater during the past year, with large surplus quantities backing up on the market, the price for the different grades ranging from 30c. to 50c., according to quality and quantity, as against 50c. to $1.20 last year.

Naphthalene.—The production has been materially augmented but with only comparatively small quantities being imported from England because of heavy duties, domestic manufacturers had a better opportunity to dictate prices, but the variation in price during the whole year was not great. From 8c. to 9½c. covers the range, and at the close of the year sales were consummated as high as 9¾c. for prime white flakes. Off color material sold at slightly less. The ball material was selling at 10c. to 11c. The total production in the United States was estimated at approximately 25,000 tons, as against 12,500 tons in 1916.

Phenol.—Phenol has probably been the feature of the list with prices fluctuating from day to day, and at times from hour to hour. There has been a steady demand, both for export and domestic consumption, in the making of intermediates for dyes and explosives. The production has materially increased and at times this has had more or less bearing upon prices. At the beginning of the year prices held at 53c. to 55c. and from time to time prices varied over a wide range, until the low level of 40c. was reached. Eventually, however, as surplus quantities were absorbed, a firmer undertone prevailed, until at the end of the year prices had gradually climbed back to their former position and 50c. to 53c. was the prevailing figure. About Dec. 15, however, the government began commandeering this product for use in the manufacture of explosives, and it was understood that producers were to receive 38c. a pound. In general offerings to the regular trade were restricted until such time as governmental requirements were filled. The production during 1917 was estimated at 25,000 tons as against 12,500 tons in 1916.

Intermediates

Great strides were made in the production of the intermediates and some of the problems that had not been solved in 1916 were brought to a successful conclusion in 1917, and practically every item of importance on the list was being produced. Aniline oil, following in sympathy with benzol, was produced on a lavish scale, and for a time the large quantities were being offered at a premium, but the producers finally got matters in hand to a certain extent, and from 25½c. to 26c. was the prevailing price, figuring in transactions of moment. Producers, while making large contracts over next year at these figures, were endeavoring to secure 28c., with a limited degree of success. The quality of the oil produced continued high and met with favor in the trade. While production was considerably greater than in 1916 authorities were unable to give exact figures.

Aniline Salts.—While the production followed closely that of aniline oil, the salts were more readily absorbed and prices did not reach as low levels as the former. Several producers dropped out, the field therefore being easier to check up. At the close of the year second hands were offering at 28c. and 29c., with producers asking 32c. to 34c.

Nitro Benzol.—The production was heavy for a time, and the market was flooded with supplies, but several producers discontinued this line, and the position was slightly improved, although there is still a plenitude of supplies. At present the market is quiet, with 17c. to 19c. quoted, and contracts involving large quantities have been made as low as 16c.

Toluidine.—This item was being produced by about a half dozen concerns during a part of the year; at the close there were but two factors in the field who were producing both, the *ortho* and *para*. The toluol situation has not yet affected same, and the *para* grade was bringing $2.00 to $2.25, with the *ortho* at 85c. to 90c.

Picric Acid.—The production narrowed down to a very few producers, who, for the most part, were catering almost exclusively to the Government, and but very little was procurable in the open market.

Tri Nitro Toluol.—Governmental needs have resulted in the elimination from the open market of this product.

Para Nitro Toluol.—This product was rather extensively produced, being in goodly demand with dye producers. However, the quality was not always up to specifications, with the result that those who had not been able to produce a quality product rapidly dropped out, until at present there are only two factors in the field, with $1.50 to $1.60 as the prevailing price.

Ortho Nitro Toluol.—The conditions were much the same as in para nitro toluol, with only a few factors holding sway, with 75c. quoted as the inside figure.

Metanitroparatoluidine.—This material was in goodly demand, with production restricted to a few quarters and material scarce, with $5.50 quoted.

Paranitraniline.—While during the early part of the year many producers were behind in the fulfillment of contracts, the increased demand from dye producers, however, was instrumental in increasing the production, and for the past few months it has been freely offered at $1.10 to $1.15 as against $1.60 to $1.70 last year.

Alpha Naphthylamine.—This product is closely identified with dye production, and has been produced in large quantities. Prices have declined as a result, and it was possible to do 58c. to 65c. as against $1.25 a year ago.

Dimethyl Aniline.—Of considerable importance in the production of some dyes, large quantities were manufactured and prices were not subject to much change; from 55c. to 60c. prevailed.

Diphenyl Amine.—Has been in fair demand with the producer of dyes, but of late munitions requirements have been heavy and there is but little procurable in the open market. It sold at times from 85c. to $1.00.

Para Phenylene Diamine.—The production for the most part was confined to one quarter, with a good demand. Prices have been well maintained at $3.50 to $4.00.

Metaphenylene Diamine.—Only two or three producers are in this field, and there is a goodly demand, with a scarcity at present, and $1.75 to $2.00 is quoted.

Para Nitro Phenol.—This material is used extensively in developing by photographers. Goodly quantities were produced, with the demand fair and prices at $1.50 for the powdered crude material and $2.00 for the needle crystals.

Ortho Nitro Phenol.—Was produced in goodly quantities by several concerns for a time, but most of these dropped out. The demand from fur dyers is heavy, with supplies light and prices at $1.40 to $1.50.

Beta Naphthol.—An abundance of this material has been produced; so great were the quantities on the market that prices were forced down from $2.00 to 65c. for the technical grade and from $2.75 to 85c. for the sublimed material.

Para Amido Phenol.—The production has been heavy during the past few months, and competition is keen, but the cost of raw materials tends to keep prices at a fairly high level and from $4 to $5.50 is quoted for both the hydrochloride and base. Ordinarily there is a difference in price between the two. One producer has recently placed upon the market a needle crystal which is expected to attract some attention.

H Acid.—During the year there were as many as 8 to 10 engaged in the production of this acid with a total output estimated at from 125 to 150 tons monthly, but as the demand eased off, several dropped out and at present there are about six who are producing quantities of moment. Prices vary with $2.15 as the inside figure for the paste, from $3.00 to $3.50 for the 100 per cent and $2.50 for 97 per cent.

Gamma Acid was produced in a limited way by one or two concerns, but inquiries in the market for large quantities of spot material failed to locate same, and orders for fairly large quantities were unfilled.

Neville & Winthers Acid is being produced in goodly quantities, but the demand of late has fallen off somewhat, and $2.00 is quoted for 100 per cent material in ton lots.

Benzoate of Soda.—This item has had a very interesting career since the commencement of the war in 1914. At that time we were almost wholly dependent upon Europe for our supplies. In August, 1914, it was selling at 23½c. a pound. Prices increased by leaps and bounds until in December, 1916, the soda sold for $8.50 a pound, and the acid at $10.00 to $12.00 a pound. A number of large producers entered the field, a price-cutting campaign was launched, and the weaker factions were eliminated. During the past few months inability to secure toluol has curtailed production and prices are once more in the ascendant with $3.00 to $3.50 as the prevailing prices respectively for the soda and the acid.

Salicylates were produced on rather a heavy scale, but prices are somewhat higher than they were a year ago, although the demand at present is not pressing for the sodium which is selling at $1.30 to $1.35. Salicylic acid, however, has met with a goodly demand, and there are large quantities being produced, which are selling at $1.10 to $1.30 for spot or prompt material and 85c. to $1.00 on contract for the U. S. P. grade. The technical grade is not in great demand, with price quotations at 75c. to $1.00 for spot material.

Aniline Dyes

Great progress was made in finished dye production in 1917, and the relations between producer and consumer are very satisfactory. The improvement in quality and variety has been very pronounced. In 1915 the total domestic production of aniline colors amounted to $2,470,096. The exports for the fiscal year ending June 30, 1917, were valued at $11,710,887 as against $5,102,002 for the same period in 1916. These figures include both aniline and natural dyes, however. Anilines are more than 50 per cent of the totals.

During July, August and September British India purchased dyes from us to the value of $84,967, Canada $161,581, Spain bought $105,505 worth of dyestuffs during this time and France bought to the extent of $86,379, Japan $80,073, Mexico purchased to the value of $75,353 and Italy $67,484. At the present time American color producers are well armed to compete with German dyestuff manufacturers in regard to most colors. Of late the markets on benzol, phenol and toluol have been tight, affecting domestic color producers. A number of small firms formerly making malachite green crystals have gone out of business for the want of toluol. It is noted that many firms previously engaged in other lines of business have entered the dyestuff industry and are now listed among American color producers. A cotton concern in the South, for years engaged in the cotton business, is now producing sulphur colors, and an ink firm in California who, for many years, was solely engaged in the manufacture of various inks, has entered the dye business and is now producing a lithol red. Another ink firm in Cincinnati has invested large sums of money in a plant to manufacture colors, and is now producing a metanil yellow. This same firm is making paranitraniline, from which para red is produced. To-day we find large and small manufacturers of colors from all over the United States busily engaged in experimental work. The fuchsine produced in this country rivals the German standard "Diamond" brand goods in both strength and shade. Primuline is being made here in fairly large quantities. Exporting to South China and Japan is demanding the attention of American color manufacturers as well as exporters. Pre-war figures show that Hong Kong used annually around $1,000,000 worth of dyes. Shanghai is another dye center. This section has been accustomed to using natural dyes and vegetable indigo, and the uses of aniline colors are not thoroughly understood as yet. According to reports, Germany has established centers in the leading dye districts of Japan and China for the instruction of the local dyers. It is generally thought that in order for the United States to establish a firm trade in these countries the business will have to be worked out along these lines. Some Japanese dyes are offered in the United States, however. They do not meet with the approval of important mills. Seemingly high standards have not been established in Japan as yet. The principal color made in Japan is yellow. The South American trade calls for the cheaper grades of anilines. The Spanish export trade is demanding considerable attention and orders for $150,000 worth of dyestuffs at one time are not infrequent. Spain buys some of the more difficult colors, including metanil yellow, patent blue, azo yellow, malachite green, fuchsine. All concerned are looking forward to a prosperous year in 1918, and it is expected that many of the complicated German colors will be produced during this period. At this writing there are 136 actual producers of anilines in America. The State of New Jersey leads with 47 color manufacturing plants, New York has 30 representative plants, Massachusetts is third in line with 11 plants, the Keystone State is represented by 7 plants. Other States are named in order of their importance as follows: Connecticut, Michigan, Ohio, Rhode Island, Illinois, North Carolina, Missouri, Maryland, Minnesota, Washington, Florida.

Heavy Chemicals

The production of practically every chemical under this classification during the past year was by far the heaviest in the history of the industry, and while there was a great element of speculation still noted in a number of the items, the market presented many aspects of stability. In certain items prices receded to levels that prevailed prior to the European war. At the moment of writing the entry of the United States into the conflict has had surprisingly little effect on conditions generally. However, it must be realized that the organization of the innumerable purchasing divisions in the national capital has taken a great deal of time and it was only toward the close of the year that these official organizations began to show their authority. There seems to be but little doubt current that a large number of the industries will eventually come under direct governmental control with prices fixed.

Potassium Salts.—A comparatively tame year was again reported in these products. German muriate of potash sold throughout the twelve months at about the unchanged level of $350. Moderately large quantities of Japanese muriate reached this market from time to time, and as is usual with a new product, consumers were inclined to discount

its value. The first shipments did contain a rather heavy sulphate content, and it is now stated that this and other impurities have generally been removed, so much so that the Japanese product generally commands a price close to that secured for the German material. The production from domestic sources continued in a larger way. As heretofore the Nebraska lakes furnished the bulk of the production, but it is not thought likely that the present production in this country from lake brines, cement and other sources totals as yet 15 per cent of the normal consumption before the war.

Ammonium Salts.—During the year the usual development of the trade that possibly stands out most is that fact that there were unusually large export shipments of sulphate of ammonia to England—heretofore the principal producer—and to countries that England heretofore shipped exclusively. As a matter of fact, sulphate of ammonia passed about out of the category of a domestic fertilizer material. On Oct. 1 an embargo on exports stopped this trade, but there was such little material available that the market was not noticeably affected; as a matter of fact, the high price of 7.30 double bags f.a.s. was quoted toward the close. The quotation at the beginning of the year was 4 50. *Ammonium nitrate* was a product that brought with it many disappointments toward the close of the year. After an unusually heavy export inquiry the demand suddenly ceased and prices dropped off so that to-day there is much material on the market that cannot be moved at even 19c. At times during the year the price rose to 21c. The manufacturer of this explosive has been up against a most serious problem in the matter of raw material. Upon the entering of the United States into the war the demand for anhydrous ammonia for refrigeration purposes for the enormous foodstuff supplies for the armies both at home and abroad brought the attention of the authorities to this situation. Considerable speculation had already been rife as a consequence of the heavy demand from the Allies. Toward the close of the year the government has consulted with the leading producers, and it is generally thought that an understanding has been reached whereby the production of ammonia will be principally of the liquor to the exclusion of sulphate and aqua ammonia. The nitrate manufacturers have been assured of their supplies. The government's price is 14c. *Muriate of Ammonia* (sal ammoniac) has been in increased demand and from a normal price of 5⅞c. for the gray material it is difficult to purchase the product now at 15c.

Nitrate of Soda.—The imports for the fiscal year ending June totaled the record amount of 1,261,658 tons, valued at $44,231,240. This compares with 1,071,728 tons valued at $32,129,397 during the corresponding period of 1916. Notwithstanding the enormous tonnage brought into this country prices reached new record levels, and some lots at one time changed hands at 5.25, although 5.10 was about the high level for important business. Toward the end of the year, however, there was a large amount of resale material offered, and seemingly the tonnage purchased early in the year had not been absorbed. These sales forced the market down to approximately 4.60. Of the manufactured *sodium salts* the sulphites came in for much attention, particularly *sodium sulphite* for moving picture developing. *Chlorate of soda* sold at 20c. for contract, but the production held well and generally firms not under contract at this figure had to purchase in the market at a higher level. *Acetate of soda* was another item under this classification that attracted much buying attention. At the close of the year the market was absolutely bare, and a nominal quotation of 17½ to 18c. prevailed, with sellers not inclined to quote for next year. *Nitrite of soda*, as a result of several new manufacturing sources entering the field, including an air nitrogen concern on the Coast and one of the largest explosives manufacturers, has receded from its high level of 58c. reached at one time during the year to the present level of 30c. at which contracts for 1918 are being offered. Owing to the restricted production of *silicate of soda* the product was generally at a premium throughout the twelve months. The product is one that has attracted but little additional capital, and so far the production, particularly of the 60 deg. material, has not increased sufficiently to take care of the consumption. *Sodium sulphide*, which is a by-product with the barium salts industry, has been scarce, and to-day commands a price about double that prior to the war.

Sulphuric Acid.—The feature of this all-important branch of the chemical industry during the past year has been the great scarcity of Spanish pyrites as a result of the submarine scare and the abnormally high freight rates, with the result that a large number of the acid plants heretofore burning pyrites were as a result of this situation compelled to install apparatus for the burning of brimstone. This, of course, meant radical change in the operation of the plant, requiring in many instances a new study of manufacturing problems. However, the crisis has been well met and to-day the production of sulphuric acid is by far the heaviest that has ever been recorded in the history of the American chemical industry. The entry of the American government into the war naturally would eventually make its influence felt in the chemical industry, and sulphuric acid was the product that was to feel this influence first. Until we were actually at war the markets presented rather weak aspect. Acid was to be obtained at prices representing not a great enhancement over those before the European conflict. At the moment of writing the situation has become so uncertain that many factors are predicting $80 acid by the spring and $200 oleum. This, of course, refers to acid for the outside market. It is reported, but not so far definitely confirmed, that for government account manufacturers will be compelled to furnish 66° deg. brimstone acid at $28 works, with a probability that the brimstone will be furnished by the government at a fixed price. It is understood that already some of the Southern fertilizer works have been furnished brimstone for acid manufacture at $22.00. Acid for the ordinary consumer at the close of the year was generally held at $38.00 to $40.00 for the 66-deg. brimstone, buyers' tanks, as sellers' tanks were not generally available. The government will undoubtedly sooner or later assume control of the industry, and it is reported that already consumers have been classified in four divisions, and will receive acid according to their relative classification.

Nitric Acid.—At the time we write the nitric situation has not shown particularly noticeable results of the country's entry into the war. Undoubtedly it will but with the nitrate of soda market easier and consumers not very much interested sales are not urgent. At one time during the year prices ranged from 14 to 15c. per unit, but toward the end of December 42-deg. material was available from 8c. to 8½c. per pound from various manufacturers.

Muriatic Acid.—The year was a tame one for this product. The movement was generally about what might be expected in normal times, but toward the close of the year the material was rather scarce and prices gave promise of reaching a higher level. However, values were not subject to much fluctuation during the twelve months. The scarcity of carboys tended to restrict the movement somewhat.

Acetic Acid.—The first half of the year witnessed an extremely active and heavy demand for practically all grades of acetic acid, particularly glacial. The last half of the year was featured by an extremely quiet and dull market, with the product mostly offered by second hands and probably resale material. Glacial acid sold well above the 30c. level throughout the interval, reached 36c. or 37c., and at the close was available at 33c. to 34c. Fifty-six per cent material closed at 5½c. from second hands, and a lot of 30 long tons of 80 per cent material changed hands toward the end of December at 11½c. As there is now an embargo on exports of acetic acid and acetates and the government has taken over the wood distillation industry, interesting developments are to occur.

Lactic Acid.—An increased production and rather quiet consuming demand throughout the year brought with it but little change for this commodity. The year closed a fraction above the prices ending 1916, with market conditions quiet.

Phosphoric Acid.—The production has seemingly set pace with the demand, and at the close of the year the 47-48 per cent acid was quoted at 7½c. as against practically double this price at the close of 1916.

Oxalic Acid.—While several new productions were inaugurated or planned, as yet none of them have seriously affected conditions here and the original American manufacturers continue to dominate the field. The price now current is 45 to 46c. as against 43 to 45c. at the close of

1916. Dutch oxalic acid has practically disappeared from the market as a result of freight difficulties.

Cyanides.—During 1916 the soda reached the high level of $1.75 to $1.80. Since then there has been a gradual recession and to-day second hands are offering the material at prices ranging from 44c. to 46c. as to point of shipment. The new plant of the only American producer in Vermont will increase the output here, and this of course does not tend to strengthen the market. The producers as heretofore sell only to the regular trade on contract and trading in outside lots is perforce in second hands.

Bichromates.—The production of both soda and potash continues well under the control of the leading producer, and so far there has not been a production sufficiently important to interfere with the operations of this concern which establishes the market, and prices generally follow their views. The 1917 contract price, it will be recalled, was 24c., but the outside market was generally below this during the year, although on some occasions it was slightly higher. The 1917 price is 16½c., but owing to under freight conditions from New Caledonia and the possibility of the government commandeering the chrome supplies, contracts are reported to contain a clause permitting the producer to advance prices under certain conditions incidental to these conditions. The year closes with second hands quoting jobbing lots at 17c. There are about eight plants with equipment for bichromate of soda or its equivalent production, but the production is principally confined to three producers. A new small producer plans a production for 1918. *Bichromate of potash* had a very uninteresting year. One of the three producers ceased manufacturing.

Copper Sulphate.—The export of this product is of course the mainstay of the trade and up to the end of September it revealed an increase over 1916, but toward the end of the year there was a great amount of difficulty noted in exporting and prices receded to the lowest level that prevailed for a long time. At the beginning of the year the large 99 per cent crystals were selling at 13c. to 14c., but in December, 1917, second hands were quoting Nichols brand 99 per cent large crystals as low as 8⅞ per cent, although the producers' price was 9½c. There are some eight or ten firms now equipped to manufacture this product, but as heretofore the production is principally in the hands of the Nichols Copper Company and the American Smelting and Refining Company.

Caustic Soda.—A record of events in this market during the year would be merely the tabulation of price changes practically hourly. Such speculative activity has never been witnessed off Wall Street. The production was sold undoubtedly thirty or forty times over. Bills of lading have come to light with as many as twenty-four indorsements, and in some instances a purchaser of a car of caustic found his own indorsement on the bill two or three times. The extent of this trade may be readily grasped when it is considered that there are probably a hundred firms in the various cities working on a brokerage basis and dealing exclusively in caustic soda and soda ash. At the opening of the year the spot price for 76 per cent caustic soda in New York was 4½c. From this level there was a steady climb until in September a level of 10c. was reached. Effective Oct. 1, the government placed the product on the conservation list with the result that in one day there was a drop of 2c. The export trade has grown beyond the dreams of the most optimistic member of the industry. There are no statistics available yet concerning the total of this trade, but from the port of New York alone the shipments totaled four, five and six thousand tons monthly. The works have generally been sold out during the year. The market has been exclusively in the hands of traders. When the drop occurred on Oct. 1 the market continued to weaken until at the close of the year spot cars were selling at 6¾c., New York, with contracts over 1918 from reliable dealers generally held at 6½c. works or New York. The production at the moment is in the hands of some twenty-six or twenty-eight firms. Just how large the output is no one seems to know, but it is estimated to be from 750,000 to 1,000,000 tons.

Soda Ash.—The market has been more or less a repetition of caustic soda but prices were not subject to such wild flurries. There was much speculation, but the product was not so closely controlled. The year opened with bags quoted at 2.95c., and from this there was a steady but slow climb to the high point of 4.25, which was reached late in August. In October the market eased off somewhat in sympathy with caustic soda, and remained quiet until Dec. 1, when this product was also placed on the conservation list and exports prohibited. Exports have been reaching the unusual large amounts of five, six and seven thousand tons monthly from New York alone. As was the case with caustic soda, the market was in the hands of traders during the year and the works were not generally quoting to this class of trade. The year closed with spot bags quoted at 2.75 to 2.80, and contracts over 1918 at 2.95 to 3c. The production is estimated to be from 800,000 to 1,000,000 tons, and there are possibly thirty or forty producers.

Bleaching Powder.—The year has been a disappointing one for bleach producers. The installation of chlorine cells by the large consumers resulted in a neglected market and at one time during the year there were sales as low as 50c. per hundred pounds for 35-37 per cent material from warehouse New York. The production is placed at 150,000 tons. At the close of the year there was a firmer tone prevailing, and it was difficult to shade 2c. for fresh bleach and for 1918 shipments producers were quoting from 2½c. to 2¼c.

Chlorate of Potash.—It is generally presumed that the bulk of the contract requirements for 1917 were placed at figures ranging from 70c. to 75c. These buyers covered to their regret for the production seems to have exceeded the demand somewhat as the market from second hands never reached the contract price. There has been a gradual recession of values until toward the end of the year resales on these contracts were occurring as low as 35c. The 1918 price has not been announced as we write, but a statement has been made that 40c. is too high and the probabilities are that the figure will be below this level somewhat.

Current Market Reports

The Iron and Steel Market

Iron and steel prices as set by the War Industries Board and the American Iron and Steel Institute are likely to stand for some time. Conferences between the War Industries Board and the Federal Trade Commission and the iron and steel makers held during December have not indicated any strong desire upon the part of the Washington authorities to seek a downward revision of prices at this time, while the manufacturers have no hope of securing an upward revision. The Federal Trade Commission will probably push the Pomerene iron and steel price-fixing bill in Congress, with a proviso for the abrogation or suspension of some contracts. The trade commission has been rather puzzled at the wide diversity of costs shown in reports it has been receiving during the past six months, some being so high that a reduction in the set prices might operate to decrease production, and its only hope of paving the way for reductions appears to be in removing the effect of some high-priced contracts for raw materials. The Pomerene bill could hardly be passed before some time in February, and as it would merely empower the President to act it would be some time before real action would be taken, if indeed any at all were taken.

Commercial Demand Very Light

The ordinary commercial demand for iron and steel has become extremely light, while during the second half of December practically none of the demand that may exist has been expressed. Buyers have been busy with year-end adjustments, particularly complicated this year, and have had no interest in the market.

Buying by the government has continued heavy, if indeed it has not increased. It is estimated that about 1,200,000 tons of the 1,500,000 tons of shell steel required for delivery by the middle of June has now been placed. A very considerable tonnage has already been produced, as shown by the relatively free offerings of discard steel in the open market. This material will be rolled into billets down to 1½ in., and is offered at about $2.50 below the set prices for soft steel billets. There is no precise information as to other steel re-

quirements of the government, but orders are being placed right along.

A comprehensive program involving cars and locomotives has been worked out at Washington against any decision that may be reached as to what is to be done with the railroads. This is a measure of preparedness, as, whether purchases of rolling stock to increase the capacity of the railroads are to be financed by the railroads or by the government, it will be necessary for the government's authority to be used to secure the earliest delivery of the raw materials for the rolling stock and its earliest manufacture.

Traffic Conditions

Traffic conditions as affecting the iron and steel industry have been worse in the second half of December than in the first half. In the Central West generally there has been a shortage of both coke and coal deliveries, worst along the lake front, with the Youngstown district coming next and the immediate Pittsburgh district faring relatively well, though suffering considerably. Production in the South has been fully up to normal, while conditions have been fair in the East. December production as a whole has been 5 to 10 per cent under the average of the first eleven months of the year, in which period there was production at 90 to 95 per cent of theoretical capacity.

The railroads were greatly affected by the cold wave of Dec. 8, which brought an average of zero weather to the Central West. Although the coldest weather lasted only about three days the railroads have not recovered. The difficulty is not so much congestion, as the operation of the pool of Eastern railroads had relieved conditions materially in that respect, as it is a shortage of motive power, evidently resulting from many locomotives having been incapacitated during the cold snap.

It is a small thing apparently that stands in the way of full production in the iron and steel industry, the movement of a little more coke and a little more coal, and it seems strange that the railroads have been unable to compass the extra movement. On the other hand, it is quite possible that if there were the extra production it would be impossible to move the additional finished product or serve the manufacturing consumers who would receive it. While there is a great deal of talk it is not made clear that the war activities or the ordinary peace activities of the people are really suffering from a shortage of steel.

Pig Iron

The demand for pig iron from iron foundries is light. While deliveries have been curtailed through irregular operation of merchant furnaces, the consumption of the iron foundries in general has undergone a great decrease. The steel works are all more or less short of pig iron and would buy in the open market, but there are practically no offerings. If the furnaces were in position to sell they would sell only at the set prices, based on $33 at furnace. Some Alabama basic iron has been sold in the Pittsburgh district at this furnace price, involving a freight of $4.55, when if the iron had been bought in the valleys the freight would have been only 95 cents.

Finished Steel

With total output curtailed steel is being put into the forms most needed. Shell steel production is practically up to requirements, being chiefly a blooming-mill proposition. The plate mills are almost fully supplied, slabbing mills being operated full while all the blooming-mill slabs possible are being made. Sheet bars are being fully supplied to tin mills, which are operating at about 95 per cent, while supplies to sheet mills are correspondingly light, entailing an average operation of 50 to 60 per cent by the sheet mills. Production of welded-steel tubular goods is off somewhat, but shipments of oil-country goods in particular are well maintained. Wire production is somewhat curtailed.

Non-Ferrous Metal Market

Wednesday, Dec. 26.—The copper situation is somewhat easier, and signs are evident of larger supplies being available owing to reduced consumption and foreign shipments. Straits tin is very scarce. Lead is unchanged. Spelter has been dull and a little weaker.

Copper.—A meeting was held in Washington on Dec. 14 between the War Industries Board and representatives of the copper producers, to discuss the copper question for 1918 as regards requirements and prices. The producers, especially some of the smaller ones, said that present copper prices were not high enough to stimulate maximum production. Assurances were given that the producers could meet the country's needs. Lake and electrolytic remain at 23.50 cents with 24.67½ as the jobbers' price.

Tin.—Tin has been very scarce and at present there is no Straits tin on the market. Arrivals to Dec. 19 were only 1115 tons, and if any were for sale it probably would bring somewhere between 85 and 90 cents. The production of American electrolytic tin is said to be relieving the situation somewhat. Fortunately the demand does not appear to be extra heavy. All grades are very scarce.

Lead.—After a long conference on Dec. 17 between representatives of the principal lead producers of the country and the War Industries Board of the Council of National Defense, it was announced that no regulatory action affecting the industry would be advocated at this time. The question of fixing prices and providing for distribution of the lead output under Government control was discussed at length, and it is understood that the producers promised co-operation on the present basis, which was satisfactory to the board. The Trust price of 6.25 New York remains unchanged. Outsiders are asking 6.50 to 6.75.

Spelter.—This market has been dull, with prompt prime Western quoted at around 7.50 St. Louis, and brass special at 8.00 St. Louis.

Antimony.—There is no change in antimony. Prices remain at 15 cents for prompt delivery, with needle antimony at 9¼ to 9½. Antimony ore is quoted at $1.75.

Tungsten.—The market has been firm in New York. Charles Hardy says that "on account of a very large foreign inquiry coming in at the same time as one of our largest users at home appeared into the market, the tungsten market has been exceedingly firm during the past week and most good grade ore in New York found ready buyers. even material on steamers shortly due was readily absorbed by the market. The tungsten price remained very steady at a slight advance and $24.50 was paid for high-grade wolframite, with prices ranging lower for off-grade ore. Such scheelite as was offered was readily sold at $26 per unit."

Molybdenum.—Demand for molybdenite is reported good and prices range from $2.25 to $2.30.

Chrome.—Very little high-grade chrome ore is offered, and the demand is good. The price remains at 90c. per unit, at California.

Quicksilver.—Very little spot material is available, as arrivals are very slow. California virgin is quoted at $115, but higher prices have probably been paid.

Other Metals

Aluminium, lb.	36–38
Bismuth, lb.	3.50
Cadmium, lb.	1.50
Nickel, electrolytic, lb.	.55
Silver, oz.	.86⅝
Platinum, oz.	105.00
Palladium, oz.	130.00

Chemical Market

Coal Tar Products.—Interest continues to center in this branch of the industry, although there has not been as much activity of late as heretofore. The government has added phenol to the conservation list, and it is unlikely that any material quantity will be released for ordinary commercial purposes. With both this product and toluol practically off the market the result is at least a temporary lull in trading. The situation in general is interesting and holds forth promise of future developments that may cause further decrease in supplies of essentials.

Benzol.—Continues weak. Large surplus stocks continue available at low figures and further concessions are believed possible.

Toluol.—The situation affecting this product is unchanged. There is practically none to be secured in the open market, the entire supply being in the hands of the government.

Naphthalene is firm and the market is quite bare of supplies, but a replenishment is expected shortly.

Phenol.—The government has taken over practically the whole production, and but little is available for ordinary trade requirements.

Benzoate of Soda is scarce and firm, with a fair demand, but only light stocks are held.

Monochlorbenzol.—The production is heavy and large surplus stocks are procurable at favorable prices.

Paranitraniline is being produced in large quantities, but there has been a better demand of late.

Metanitraniline continues to be offered in a liberal way, with the demand light.

Aniline Salt is slightly firmer, with second hands pretty well cleaned out and producers in command of the situation.

Aniline Oil spot stock continues to be offered in a liberal way at fair prices, but an advance is expected on business over next year.

Para Toluidine.—The market is firm, with production restricted on account of the toluol situation.

Ortho Toluidine.—While the demand is not heavy, production is somewhat restricted and the position is firm.

Tolidin continues to be in fair supply, but concessions are impossible because of the light supply of toluol.

Antracene is in goodly demand, but there is a scarcity. A recent large sale appears to have cleaned out available supplies and higher prices are obtained.

Para Nitro Phenol is in goodly demand, with a fair production, and prices are unchanged.

Ortho Nitro Phenol.—At present the demand is greater than the supply, but new producers are entering the field. Prices are unchanged.

Salicylic Acid has been sold in large quantities of late, with prices unchanged because of large production.

Nitro Benzol has figured in goodly sales of late, but the production is heavy and prices are low.

Beta Naphthol has been in better demand of late, but large surplus quantities tend to keep prices down.

HEAVY CHEMICALS.—As is usual in December, there is a quiet and generally a weak market prevailing. This December has been no exception to this rule, and trading during the past two weeks has been of a very minor character, with prices generally inclined downward. Oddly a few items that have been quiet practically throughout the year end the year with a strong feeling prevailing.

Caustic Soda.—A much easier market has prevailed since our last report, and selling pressure has resulted in a spot price of about 6¾c. ex-store. This new figure is probably accounted for by the fact that some second hands in fear of a lower 1918 market have liquidated their holdings. For 1918 deliveries most of the reliable factors quote 6.50 for two or three cars monthly from the works. Other traders are quoting lower but the usual uncertainty regarding deliveries makes a buyer hesitate somewhat before closing with these firms.

Soda Ash.—Real soda ash is not easily obtained for nearby positions. This condition of affairs is readily discovered if a buyer attempts to cover. The demand for spot and nearby, however, is fortunately for buyers not particularly heavy, and the market remains more or less inactive. Over 1918 there are sellers quoting 2.95 to 3c. for bags. Barrels are generally held at 3.15 works, but one contract from New York is available at a lower figure.

Copper Sulphate.—The market has been subject to a sharp drop. Nichols brand from second hands has been offered as low as 8⅞c., although the producers still quote 9¼c. to 9½c. The lack of export trading is the cause of the present slump.

Cyanides.—There has been no change of special moment. Offers from second hands are reported from various points at prices ranging from 44c. to 45c. for the sodium. The so-called potassium has seemingly disappeared from the market. The new plant in Vermont will result in an increased 1918 output.

Bleaching Powder.—After practically twelve months of inactivity there are now more orders in the market than can seemingly be filled. Bleach for prompt shipment from works has been quite active, and buyers have found it difficult to cover generally. For 1918 business 2¼c. is generally quoted as a minimum price but 2⅛c. is named as one contract figure.

Chlorate of Potash.—As we write the 1918 price has not been publicly announced. There is much speculation as to the figure. It is generally assumed that it will be somewhat below 40c. The second hand market has been quiet and generally easy during the two weeks. Sales have occurred at 42c. and even 44c., but some firms anxious to dispose of contract material have offered several hundred kegs at even lower figures.

Acids.—As a result of the extensive government requirements and the fact that the acid production is now much oversold, the market for sulphuric acid has become almost nominal. There are offers reported from second hands, and these range from $38 to $40, buyers' tanks or drums returnable. *Oleum* has already reached the $60 level and promises to pass that point soon. *Nitric Acid* has not been so firm. As yet there has been no pronounced demand. Nitrate of soda has been easier, but sulphuric is higher and an important demand will no doubt send prices higher. *Muriatic acid* has after a period of quietness become quite scarce and prices are somewhat firmer.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, DEC. 26, 1917

Acetic anhydride	lb.	1.80 —	1.90
Acetone, drums	lb.	.36 —	.37
Acid, acetic, 28 per cent	lb.	.05½ —	.06
Acetic, 56 per cent	lb.	.11¾ —	.12¼
Acetic, glacial, 99½ per cent, carboys	lb.	.35 —	.40
Boric, crystals	lb.	.12¾ —	.14¾
Citric, crystals	lb.	.75 —	.78
Hydrochloric, C.P.	lb.	.08¼ —	.08¾
Hydrochloric, 20 deg.	lb.	.02½ —	.02½
Hydrochloric, C.P., conc., 22 deg.	lb.	.02½ —	.02¾
Hydrofluoric, 30 per cent, in barrels	lb.	.06¼ —	.06½
Lactic, 44 per cent	lb.	.15 —	.15½
Lactic, 22 per cent	lb.	.05½ —	.06½
Nitric, 36 deg.	lb.	.08 —	.08½
Nitric, 42 deg.	lb.	.08¾ —	.09
Oxalic, crystals	lb.	.45 —	.46
Phosphoric, 47 per cent-50 per cent	lb.	.07½ —	.....
Picric	lb.	Nominal	
Pyrogallic, resublimed	lb.	3.15 —	3.25
Sulphuric, 60 deg.	ton	..... —	.....
Sulphuric, 66 deg.	ton	..... —	.....
Sulphuric, oleum (fuming), tank cars	ton	60.00 —	80.00
Tannic, U. S. P., bulk	lb.	1.30 —	1.35
Tartaric, crystals	lb.	.76 —	.78
Tungstic, per lb. of W	lb.	1.80 —	1.90
Alcohol, sugar cane, 188 proof	gal.	5.05 —	5.25
Alcohol, wood, 95 per cent	gal.	1.35 —	1.40
Alcohol, denatured, 180 proof	gal.	.78 —	.80
Alum, ammonia lump	lb.	.04½ —	.05
Alum, chrome ammonium	lb.	.18½ —	.19
Alum, chrome potassium	lb.	Nominal	
Alum, chrome sodium	lb.	.12½ —	.13
Alum, potash lump	lb.	.08 —	.09
Aluminium sulphate, technical	lb.	.02½ —	.03¼
Aluminium sulphate, iron free	lb.	.03½ —	.04
Ammonia aqua, 26 deg. carboys	lb.	.18 —	.19
Ammonium carbonate	lb.	.10 —	.11
Ammonium nitrate	lb.	.19 —	.21
Ammonium, sulphate domestic	lb.	.07¼ —	.07⅜
Amyl acetate	gal.	5.25 —	5.40
Arsenic, white	lb.	.15 —	.16
Arsenic, red	lb.	.65 —	.70
Barium carbonate, 99 per cent	ton	80.00 —	90.00
Barium carbonate, 97-98 per cent	ton	65.00 —	67.00
Barium chloride	ton	70.00 —	90.00
Barium sulphate (Blanc Fixe, powder)	lb.	.03½ —	.04
Barium nitrate	lb.	.10½ —	.11
Barium peroxide, basis 70 per cent	lb.	.32 —	.38
Bleaching powder, 35 per cent chlorine	lb.	.02 —	.02¼
Borax, crystals, sacks	lb.	.07¼ —	.08¼
Brimstone, crude	ton	Nominal	
Bromine, technical	lb.	.65 —	.70
Calcium, acetate, crude	lb.	.06 —	.06⅛
Calcium, carbide	lb.	.08½ —	.09
Calcium chloride, 70-75 per cent, fused, lump	ton	21.00 —	22.00
Calcium peroxide	lb.	1.60 —	1.70
Calcium phosphate	lb.	.30 —	.31
Calcium sulphate	lb.	..... —	.....
Carbon bisulphide	lb.	.07 —	.07½
Carbon tetrachloride, drums	lb.	.15 —	.16
Caustic potash, 88-92 per cent	lb.	.82½ —	.....
Caustic soda, 76 per cent	lb.	.06¾ —	.07
Chlorine, liquid	lb.	.15 —	.18
Cobalt oxide	lb.	1.40 —	1.50
Copperas	lb.	.01¼ —	.01½
Copper carbonate	lb.	.45 —	.....
Copper cyanide	lb.	.75 —	.78
Copper sulphate, 99 per cent, large crystals	lb.	.09 —	.09½
Cream of tartar, crystals	lb.	.56 —	.57
Epsom salt, bags	lb.	.03¼ —	.04
Formaldehyde, 40 per cent	lb.	.18 —	.20
Glauber's salt	100 lb.	.90 —	1.10
Glycerine, bulk, C. P.	lb.	.69 —	.70
Iodine, resublimed	lb.	4.25 —	4.35
Iron oxide	lb.	.13 —	.15
Lead, acetate, white crystals	lb.	.17 —	.17½
Lead arsenate	lb.	.15 —	.18
Lead nitrate	lb.	Nominal	
Litharge, American	lb.	.09½ —	.11½
Lithium carbonate	lb.	1.50 —	2.00
Manganese dioxide, U. S. P.	lb.	.48 —	.55
Magnesium carbonate, tech.	lb.	.10 —	.10½
Nickel salt, single	lb.	.14 —	.15
Nickel salt, double	lb.	.11½ —	.....
Phosphorus, red	lb.	1.70 —	.....
Phosphorus, yellow	lb.	1.25 —	.....
Potassium bichromate	lb.	.45 —	.46
Potassium bromide granular	lb.	1.45 —	1.50

Potassium carbonate calcined, 85-90 per cent	lb.	.65	—	70
Potassium chlorate, crystals	lb.	.42	—	.44
Potassium cyanide, 98-99 per cent	lb.	Nominal		
Potassium iodide	lb.	3.75	—	3 80
Potassium muriate 80-85 p.c. basis of 80 p.c.	ton	350.00	—	
Potassium nitrate	lb.	.28	—	.30
Potassium permanganate	lb.	4.10	—	4.25
Potassium prussiate, red	lb.	2.40	—	2.50
Potassium prussiate, yellow	lb.	1.25	—	1.35
Potassium sulphate, 90-95 p.c. basis 90 p.c.	ton	Nominal		
Rochelle salts	lb.	.39	—	.39½
Salammoniac, gray gran.	lb.	.15	—	.16
Salammoniac, white gran.	lb.	Nominal		
Sal soda	100 lb.	1.15	—	1.25
Salt cake	100 lb.	1.50	—	2.00
Silver cyanide, based on market price of silver	oz.			
Silver nitrate	oz.	.52	—	.55
Soda ash, 58 per cent. light, flat	100 lb.	2 80	—	2 90
Soda ash, 58 per cent, dense, flat	100 lb.	4 00	—	4 05
Sodium acetate	lb.	Nominal		
Sodium benzoate	lb.	3 00	—	
Sodium bicartonate, domestic	lb.	.02¾	—	.03
Sodium bicarbonate, English	lb.			
Sodium bichromate	lb.	.17	—	.18
Sodium bisulphite, powd.	lb.	.06¼	—	.06½
Sodium chlorate	lb.	.24½	—	.25
Sodium cyanide	lb.	.45	—	.46
Sodium fluoride, commercial	lb.	.18½	—	
Sodium hyposulphite	lb.	.02	—	.02¼
Sodium molybdate, per lb. of Mo	lb.	2.50	—	
Sodium nitrate, 95%	100 lb.	4.65	—	4.75
Sodium nitrite	lb.	.30	—	.35
Sodium peroxide	lb.	.45	—	.48
Sodium phosphate	lb.	.04	—	.04½
Sodium prussiate, yellow	lb.	.35	—	.36
Sodium silicate, liquid	100 lb.	1.80	—	2.00
Sodium sulphide, 30 per cent crystals	lb.	.02¾	—	.03
Sodium sulphide, 60 per cent, fused	lb.	.01½	—	.05
Sodium sulphite	lb.	.05	—	.06
Strontium nitrate	lb.	.25	—	.35
Sulphur chloride, druma	lb.	.06	—	.06½
Sulphur dioxide, liquid, in cylinders	lb.	.15	—	.40
Sulphur, flowers, sublimed	100 lb.	4.05	—	4 10
Sulphur, roll	100 lb.	3 70	—	3.85
Sulphur, crude	ton	Nominal		
Tio bichloride, 50 deg.	lb.	Nominal		
Tio oxide	lb.	.85	—	1.00
Zinc carbonate	lb.	.22	—	.25
Zinc chloride	lb.	.10½	—	.11
Zinc cyanide	lb.	Nominal		
Zinc dust 350 mesh	lb.	.17	—	.18
Zinc oxide, American process XX	lb.	.11¾	—	.12
Zinc sulphate	lb.	.06	—	.07

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.35	—	.40
Benz l, 90 per ce t	g l.		—	
Toluol, pure water white	gal.	Nominal		
Xylol, pure, water white	gal.	.35	—	.50
Solvent naphtha, water white	gal.	.17	—	.22
Solvent naphtha, crude, heavy	gal.	.13	—	.16
Creosote oil, 25 per cent	gal.	.34	—	.35
Dip oil, 20 per cent	gal.	.29	—	.30
Pitch, various grades	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05	—	1.10
Carbolic acid, crude, 50 per cent	lb.	.60	—	.65
Carbolic acid, crude, 25 per cent	lb.	.32	—	.35
Cresol, U. S. P.	lb.	.19	—	.20

Intermediates, Etc.

Apha naphthol, crude	lb.	1 10	—	
Alpha naphthol, distilled	lb.	1 60	—	
Alpha naphthylamin	lb.	.58	—	.60
Aniline oil, drums extra	lb.	.26	—	.27
Aniline salts	lb.	.32	—	.34
Anthracene, 80 per cent	lb.	.50	—	.65
Benzaldehyde	lb	4 00	—	4 50
Benzidine, base	lb.	1.80	—	1.85
Benzidine, sulphate	lb.	1.40	—	1.50
Benzoic acid	lb.	3.25	—	3.50
Benzyl chloride	lb.	2 50	—	2 75
Beta naphthol benzoate	lb.	7.00	—	8.00
Beta naphthol, sublimed	lb.	.85	—	90
Beta naphthylamin com.	lb.	2.50	—	2.65
Dichlor benzol	lb.	.12	—	.18
Diethylaniline	lb.	3.75	—	4.25
Dinitro benzol	lb.	.34	—	.50
Dinitrochlorbenzol	lb.	.40	—	.42
Dinitronaphthaline	lb.	.55	—	.60
Dinitrotoluol	lb.	.55	—	.60
Dinitrophenol	lb.	.55	—	.57
Dimethylaniline	lb.	.85	—	1 00
Diphenylamine	lb.	.85	—	1 00
H-acid	lb.	3.00	—	3.50
Metaphenylenediamine	lb.	1.75	—	1.80
Monochlorbenzol	lb.	.19	—	.22
Naphthalene, flake	lb.	.09½	—	.10
Naphthalene, balls	lb.	.10½	—	.10¾
Naphthionic acid, crude	lb.	1.50	—	1 75
Naphthylamin-disulfonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.45	—	.50
Nitro toluol	lb.	.50	—	.55
Ortho-amidophenol	lb.			
Ortho-toluidine	lb.	.90	—	1.00
Orth-nitro-toluol	lb.	.75	—	1.00
Para-amidophenol, base	lb.	4 00	—	5 50
Para-amido-phenol, H. Ch.	lb.	4 50	—	5 50
Paranitraniline	lb.	1.10	—	1.15
Para-nitro-toluol	lb.	1.50	—	1.60
Paraphenylenediamine	lb.	3.50	—	4.00
Para toluidine	lb.	2.25	—	
Phthalic acid anhydride	lb.	6.30	—	6.40
Phenol, U. S. P.	lb.	.52	—	.53
Resorcin, technical	lb.	8.00	—	9 00
Resorcin, pure	lb.	13.00	—	13.50
Salicylic acid	lb.	1.20	—	1.30
Salol	lb.	1.85	—	2.00
Sulphanilic acid	lb.	.32	—	.35
Toludin	lb.	2.50	—	
Toluidine-mixture	lb.	.75	—	85

Petroleum Oils

Crude (at the Wells)				
Pennsylvania	bbl.	3.75	—	
Corning, Ohio	bbl.	2 80	—	
Somerset, Ky.	bbl.	2 55	—	
Wooster, Ohio	bbl.	2.38	—	
Indiana	bbl.	1.98	—	
Illinois	bbl.	2.12	—	
Oklahoma and Kansas	bbl.	2.00	—	
Caddo, La., light	bbl.	2.00	—	
Corsicana, Tex., light	bbl.	2.00	—	
California	bbl.	.98	—	1.32
Gulf Coast	bbl.	1.00	—	
Fuel Oil				
New York	gal.	.11	—	
Pittsburgh	gal.	.07½	—	10
Oklahoma-Kans.	bbl.	1.50	—	2 35
Texas	bbl.	1.50	—	1.75
Los Angeles	bbl.	1 52	—	
San Francisco	bbl.	1.45	—	
Gasoline (Wholesale)				
New York	gal.	.24	—	
Boston	gal.	.25	—	
Pittsburgh	gal.	.26	—	
Chicago	gal.	.21	—	
Oklahoma	gal.	.25	—	
San Francisco	gal.	.20½	—	

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	18	—	.19
Cylinder, light	gal.	32	—	.33
Cylinder, dark	gal.	30	—	.31
Paraffine, high viscosity	gal.	.35	—	.36
Paraffine, .903 sp. gr.	gal.	27	—	.28
Paraffine, .865 sp. gr.	gal.	19	—	20

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f.o.b. Florida	gal.	.44	—	
Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.50	—	
Pine oil, destructively distilled	gal.	.43	—	.53
Pine-tar oil, sp. gr. 1.025-1.035	gal.	.30	—	
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.35	—	
Pine oil, light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—	
Pine oil, heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.26	—	
Pine tar, thin, sp. gr. 1.060-1.080	gal.	.32	—	
Turpentine, crude, sp. gr. 0.980-1.000	gal.	.40	—	
Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990	gal.	.21	—	
Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08	gal.	.19½	—	
Wood creosote, ref. f.o.b. Florida	gal.	.30½	—	

Vegetable and Other Oils

China wood oil	lb.	19½	—	.20½
Cottonseed oil, crude	gal.	1.31	—	
Linseed oil, raw, cars	gal.	1 25	—	
Peanut oil, crude	gal.	1.37	—	
Rosin oil, first run	gal.	.35	—	
Rosin oil, fourth run	gal.	.66	—	
Soya bean oil, Manchuria	lb.	.17¼	—	.17½
Turpentine, spirits	gal.	.50	—	.51

Miscellaneous Materials

Barytes, floated, white, foreign	ton	40.00	—	50.00
Barytes, floated, white, domestic	ton	30.00	—	36.00
Beeswax, white, pure	lb.	.56	—	.64
Casein	lb.	.22	—	.30
Chalk, light, precipitated, English	lb.			
Feldspar	ton	8.00	—	12.00
Fuller's earth, powdered	100 lb.	1.00	—	1.50
Ozokerite, crude, brown	lb.	.65	—	.75
Ozokerite, American, refined, white	lb.	.75	—	1.00
Red lead, dry, carloads	lb.	.10	—	.11¼
Rosin, 280 lb.	bbl.	7.20	—	
Soapstone	ton	10.00	—	12.50
Talc, American, white	ton	15.00	—	22.00
White lead, dry	lb.	.09	—	.10

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	Nominal		
Chrome cement, Grecian	net ton	Nominal		
Clay brick 1st quality fireclay	per 1000	50 00	—	55.00
Clay brick, second quality	per 1000	35 00	—	40.00
Magnesite, raw	ton	30 00	—	35 00
Magnesite, calcined	ton	40.00	—	55.00
Magnesite, Grecian, dead burned	net ton	85 00	—	90 00
Magnesia brick, Grecian, 9x4½x2½	net ton	135.00	—	140.00
Silica brick	per 1000	50.00	—	60.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f.o.b. Niagara Falls, N. Y.	ton	160.00	—	
Ferrochromium, per lb. of Cr	lb.	.40	—	.45
Ferromanganese, domestic	ton	250 00	—	
Ferromanganese, English	ton	325.00	—	
Ferromolybdenum, per lb. of Mo	lb.	5 00	—	
Ferrosilicon, 75 per cent, f.o.b. N. Y.	ton			
Ferrosilicon, 50 per cent, carloads, del., Pittsburgh	ton	160 00	—	
Ferrosilicon, 50 per cent, contract	ton	100 00	—	175.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	2.35	—	2.45
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.00	—	
Ferrovanadium, f.o.b. works	lb.	3.50	—	4.50

Ores and Semi-finished Products

Antimony ore, per unit		1 60	—	1.75
Chrome ore, 48 per cent minimum, f.o.b. Cal., per unit	ton			.90
Manganese ore, 48 per cent and over, per unit	ton			1 20
Manganese ore, chemical	ton	80 00	—	100.00
Molybdenite, per lb. of MoS_2	lb.	2.25	—	2 30
Tungsten, Scheelite, per unit of WO_3	ton	22 00	—	
Tungsten, Wolframite, per unit of WO_3	ton	23 00	—	26 00
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium Pentoxide, 99%	lb.			10.50
Pyrites, foreign	unit	.16	—	.16½
Pyrites, domestic	unit	25	—	.30

INDUSTRIAL

Financial, Construction and Manufacturers' News

New Companies

THE ALLOY FOUNDRY & MACHINE COMPANY, New Rochelle, N. Y. Capital, $10,000. To operate a plant for the manufacture of castings. Incorporators: Arthur C. Wakeling, Walter F. Wollheim and Gustav C. Pansegrau, New Rochelle.

THE AMALGAMATED CORPORATION, Dover, Del. Capital, $335,000. To manufacture tools of various kinds.

THE AUTOMATIC SHELL-BORING MUNITIONS COMPANY, Philadelphia, Pa. Capital, $100,000. To manufacture dynamite, gunpowder and other explosives. Incorporators: Cyrus Hawkins, Samuel Hough and Russell H. Myers, Philadelphia.

THE BARNHARD FERTILIZER COMPANY, Frankfort, Ind. Capital, $100,000. To engage in the manufacture of fertilizers and kindred products. Incorporators: Clifton W. Cobee, Samuel L. Barnhard and Raymond E. Steward.

THE CAMBRIDGE FOUNDRY & MACHINE COMPANY, Cambridge, Ohio. Capital, $50,000. To operate a local plant. Mark A. Copeland is the principal incorporator.

THE CENTRAL PIGMENT COMPANY, Dover, Del. Capital, $250,000. To engage in a general mining business.

THE T. J. COOPER RUBBER COMPANY, INC., Jersey City, N. J. Capital, $75,000. To manufacture rubber tires. Incorporators: W. Metkiff, J. McLaren and R. Rudolph.

THE COSBY CHEMICAL COMPANY, Chicago, Ill. Capital, $150,000. To manufacture chemicals and allied products. Incorporators: G. H. and J. I. Childs and John H. Mulligan, Chicago.

THE CRAVIER FOUNDRY COMPANY, INC., Rochester, N. Y. Nominal capital, $5,000. To operate a local foundry. Incorporators: L. C. Graves, J. T. Cravier and T. Hanlon, Jr., all of Rochester.

THE DETROIT FUEL & FOUNDRY SUPPLY COMPANY, Detroit, Mich. Capital, $75,000. To engage in the manufacture of foundry supplies, etc. Incorporators: Webster L. Sallee, John T. Hornbrook and Frank I. Cornwall, Detroit.

THE DETROIT MICA COMPANY, Detroit, Mich. Capital, $10,000. Incorporators: James E. Burgess, C. A. Bromley and C. J. Thorp, Detroit.

THE FORE CHEMICAL WORKS, INC., Jersey City, N. J. Capital, $475,000. To manufacture chemicals and kindred products. Incorporators: R. E. Breed, M. W. Alexander and U. M. Fleischman, all of Wilmington, Del.

THE FOUR GASOLINE COMPANY, Dover, Del. Capital, $100,000. To extract gasoline from natural gas, etc.

THE GREAT NORTHERN STEEL & IRON COMPANY, Duluth, Minn. Capital, $500,000. To engage in the mining, smelting, reducing and refining of metals and the manufacture of iron and steel products. Incorporators: E. C. Kennedy, Frank L. Swan and N. C. Johnston, all of Duluth.

THE DORRITE INSULATION COMPANY, INC., 188-192 Culver Avenue, Jersey City, N. J., has been incorporated with a capital stock of $200,000. Harry A. Dorr is vice-president; Robert D. Radcliffe, Jr., treasurer, and R. D. Adams, secretary. A large two-story brick building is now being equipped. The factory will be in operation about Feb. 1, 1918. The company proposes to manufacture "Dorrite," an insulating material, which may be molded, stamped or pressed into all special or commercial sizes and shapes for all electrical insulating uses.

THE L. H. BUTCHER COMPANY, New York and San Francisco, has been incorporated under the laws of New York to manufacture and deal in colors, chemicals, minerals and industrial ores. Principal offices, 100 William St., New York. Officers: S. L. Schwartz, president; J. E. Schwartz, vice-president (both of San Francisco); Virgil G. Thomas treasurer and secretary, New York.

THE HIGH SPEED STEEL PRODUCTS CORPORATION, New York. Capital, $27,500. Incorporators: A. F. McCabe, P. H. Butchorn and A. E. Moore, 37 Wall Street.

THE INTERCONTINENTAL PRODUCTS CORPORATION, New York. Nominal capital, $5,000. To manufacture chemicals, dyestuffs and kindred products. Incorporators: D. D. H. Minassian, M. J. Gourland and L. Haim, 253 West Seventy-second Street.

THE INTERNATIONAL NITRO-FIX COMPANY, Wilmington, Del. Capital, $250,000. To manufacture chemicals, nitrogen compounds, etc. Incorporators: William S. Hilles, La-Penne Guenvuer and R. J. Brenneisen, all of Wilmington.

THE INTERNATIONAL STEEL TUBE & ROLLING MILLS, INC., Cleveland, Ohio. Capital, $2,500,000. To operate a plant for the manufacture of tubing, etc. Incorporators: O. R. Grimmesey and C. H. Hopkins.

THE JAHANT FOUNDRY & HEATING COMPANY, Akron, Ohio. Capital, $100,000. To operate a local plant. Incorporators: H. F. McGill, Philip B. Treash, A. H. Cumming, C. Blake McDowell and F. France, Akron.

THE JOHNSON-PYROLIN CORPORATION, Washington, D. C. Capital, $1,000,000. To manufacture fireproofing and fire-resisting paints, oils, etc. Incorporators: T. G. Brady, J. H. Huston and E. R. Turner, all of Washington.

THE KYUNE COMPANY, Wilmington, Del. To engage in the manufacture of iron products. Incorporators: K. E. Longfield, F. D. Buck and M. L. Horty, all of Wilmington.

THE L. J. LEWERY COMPANY, New York. Capital, $200,000. To deal in iron and steel products. Incorporators: S. B. Howard, George V. Reilly and A. W. Britton, 65 Cedar Street.

THE LIBERTY METAL PRODUCING COMPANY, Westcliffe, Col. Capital, $400,000. To conduct a general mining business. Incorporators: Jacob Abelson, D. W. Kahane and I. H. Kuhn.

THE LUMMUS MACHINERY COMPANY, Spartanburg, S. C. Capital, $10,000. To manufacture machinery of various kinds. Incorporators: J. L. Lummus and Robert E. Carter, Spartanburg, and A. L. Lummus, Saluda, N. C.

THE METALOID COMPANY, Bayonne, N. J. Capital, $25,000. To manufacture chemicals and allied products. Incorporators: Thomas Brady, Joseph E. Gerry and James Benny, all of Bayonne.

THE MIAMI ZINC & LEAD SYNDICATE, Miami, Okla. Capital, $5,000,000. To engage in a general smelting and refining business. Incorporators: C. C. Slaughter, Jr., L. P. Gamble, Dallas, Tex.; E. P. Mix, W. H. Logan and D. Rice, Miami, and W. F. Felker and J. E. Felker, Rogers, Ark.

THE NATIONAL BEARINGS COMPANY, Dover, Del. Capital, $100,000. To manufacture ball bearings, etc. Incorporators: C. L. Rimlinger, M. M. Clancy, Wilmington, and C. M. Egner, Elkton, Md.

THE NEW ENGLAND GRAPHITE COMPANY, Augusta, Me. Capital, $200,000. To mine for graphite, talc, mica, etc., produce gas, oil and kindred products.

THE PAN-AMERICAN MANGANESE CORPORATION, Dover, Del. Canital, $3,500,000. To engage in the development of iron and manganese properties.

THE PARAFFINE COMPANIES, INC., Dover, Del. Capital, $15,500,000. To manufacture paints, paint materials and allied products.

THE PERCHLORATE EXPLOSIVES CORPORATION, Poughkeepsie, N. Y. Canital, $2,100,000. To manufacture chemicals, explosives, etc. Incorporators: C. W. H. Arnold, L. Bedell and H. B. Vosburg, Pourhkeepsie.

THE SAFETY FRAGILE ARTICLE CARRIERS COMPANY, New York. Capital, $500,000. To manufacture paper boxes, etc. Incorporators: Henry S. Gilbert, John P. Phillan, New York, and V. T. Casson, Philadelphia, Pa.

IRA L. SLOMON, INC. New York. Capital, $30,000. To manufacture varnishes, shellac, rubber, etc. Incorporators: S. Moore and M. L. and L. Slomon, 164 East Thirty-fifth Street, New York.

THE SOUTHERN PRODUCING & REFINING COMPANY, Dover, Del. Canital, $3,000,000. To engage in the production and refining of oil.

THE STANDARD METALS REDUCTION COMPANY, Chicago, Ill. Capital $2,000,000. To mine for ores and minerals of all kinds. Incorporators: J. E. Harner, James H. Ayem and T. T. Watson, all of Chicago.

THE STODDARD UNION COMPANY, INC., New York. Canital $100,000. To operate foundries. Incorporators: Earl O. Aspdin, Albert Hild and Frank B. Potterton, New York.

THE TORWILLIGER EQUIPMENT COMPANY, Dover, Del. Capital, $50,000. To operate a plant for the manufacture of engines, motors, boilers and kindred equipment.

THE UNITED STATES POTASH PRODUCTS COMPANY, White Plains, N. Y. Capital, $5,500,000. Incorporators: D. T. Connet, White Plains; J. F. Roach and C. E. Bahn, all of New York.

THE UNITED SUGAR COMPANY, Salt Lake City, Utah. Capital, $1,100,000. To manufacture sugar and all byproducts thereof. Incorporators: F. M. Lyman, Jr., A. J. Gillis, L. C. Wooley, D. F. Thomas and H. A. Strauss, Salt Lake City.

D. A. VANHORNE & COMPANY, INC., Newark, N. J. Capital, $75,000. To manufacture glassware of all kinds. Incorporators: G. and Edward B. Vanhorne and H. T. Stetson, Newark.

THE VITHUMUS COMPANY, Norfolk, Va. Capital, $975,000. To operate a plant for the manufacture of fertilizers, etc. Incorporators: R. W. Gamble, R. C. Taylor and George M. Payne.

THE WAY-CLEANSE CORPORATION, New York. Capital, $5,000,000. To manufacture special machines for the cleaning of streets, railway tracks, etc.

FRED WETZEL & COMPANY, New York. Capital, $10,000. To manufacture chemicals and kindred products. Incorporators: F. Wetzel, C. and R. Toepfer, 305 West 134th Street.

THE WYOMING SULPHUR & REFINING COMPANY, Chicago, Ill. Capital, $2,000,000. To manufacture sulphur and chemical products. Incorporators: T. W. Cole, Chicago; K. S. Wilson and M. Luce, Oak Park, Ill.

Construction and Operation

Alabama

ENSLEY.—The National Steel Products Company has acquired property on Eighth Avenue, Bessemer, and plans for the immediate construction of a plant for the manufacture of guard rails, switches, steel castings and allied railroad products. The proposed plant is estimated to cost about $25,000 and is expected to be ready for operation early in March 1918. R. S. Bohannon is president, and George A. Millar, vice-president.

BIRMINGHAM.—The Tennessee Coal, Iron & Railroad Company is considering the construction of additions to its steel plant at Fairfield, to consist of new plate and angle mills, machine shop, forge and foundry, and other structures to be devoted to the manufacture of machinery and parts for ship construction. A new open-hearth furnace and converter will be installed in the company's plant at Ensley.

MUSCLE SHOALS.—Definite steps have been taken by the United States Government in the construction of its proposed plant at Muscle Shoals, near Sheffield, to be devoted to the manufacture of ammonia, nitric acid and other chemicals employed in the manufacture of explosives. The Government has announced that the cyanamid process of air fixation will be adopted, and for this purpose the American Cyanamid Company has surrendered its process patents, data, chemicals, etc., for the duration of the war. The first unit of the new plant is expected to be completed and ready for operation within the next six months, the entire works involving an expenditure of approximately $30,000,000. Frank S. Washburn, president of the American Cyanamid Company, will be the chief adviser of the Government in the construction of the new nitrate plant. Power for the operation of the works will be furnished by the Alabama Power Company, which is under a three-year contract with the Government to that end. A new company has been formed to be known as the Air Nitrates Corporation. The officers are Frank S. Washburn, president; K. F. Cooper, vice-president; A. E. Bond, secretary, and S. M. Boyce, treasurer. The offices of the company are at 511 Fifth Avenue and 360 Madison Avenue New York. This company will act as agent of the Ordnance Department in the construction of the new plant. The officers are at the head of the American Cyanamid Co.

Two thousand two hundred acres of land lying at the foot of Muscle Shoals and at the end of the Florence River bridge at South Florence has been selected as the most desirable site, and options have been secured on practically all of the land. The work of laying railway side-tracks has been under way for a week. Several thousand feet have been laid, and the work of laying more track is being rushed.

It is said that when the Government discovered that there was but little nitrate in the country and that great quantities must be had, the situation was viewed with

alarm. The officers and engineers of the American Cyanamid Co. were called upon for help, and at once showed their patriotism by volunteering to help in every way possible, giving their services free of charge in assisting in the building of a great nitrate plant and giving the Government the use of their valuable information.

It is stated that while the great dam is being built, and as soon as the nitrate plant is ready for operation, power to the extent of 30,000 horse-power will be secured from the Alabama Power Co., and that a steam plant to be erected on the site will also furnish 30,000 horse-power.

The entire plant will be so constructed that the power from the Muscle Shoals hydro-electric development may be used as soon as it is ready.

The statement has been made that the great plant will be rushed to completion and that by the first of July munitions from the nitrate will be on the way to France.

The site selected is especially desirable. It lies about 100 feet above the waters of the beautiful Tennessee and has perfect drainage. Railroads extending to the north, south, east and west pass through it, and river transportation may be had to all points down the Tennessee and points on the Ohio and Mississippi rivers.

California

LOS ANGELES.—The United Power Company has acquired property in the San Gabriel Canyon, formerly held by the Electric Power Company, and is planning for the erection of a new power plant at Iron Fork.

McKITTRICK.—The Associated Oil Company is having plans prepared for the installation of a new dehydrating plant on its Delmonte lease in the McKittrick field.

RICHMOND.—Construction has been commenced on a new plant on a site recently acquired from the East Shore Company by the Visayan Refining Company. The property has a deep-water frontage, and the new works will be devoted to the refining of copra.

SAN FRANCISCO.—The Judson Manufacturing Company has taken out a building permit for the construction of extensive additions to its refining mill, which extends from the foot of Park Avenue to the Oakland line. The company has recently received a number of large contracts, and the additions are to provide for increased capacity.

Connecticut

BRISTOL.—The Bristol Brass Company, Forestville, near Bristol, has commenced the construction of an addition to its plant on Broad Street. The extension will be used for metal reclaiming and allied operations.

WATERBURY.—The Connecticut Brass & Manufacturing Company, a Delaware incorporation, recently perfected to take over the Connecticut Brass Corporation, West Cheshire, and the Piling Brass Company, Waterbury, has taken out authorization papers to operate in Newark. J. C. Lyon, Jr., 61 Broadway, is representative.

Delaware

NEWARK.—A portion of the salicylic acid plant of the duPont Powder Company was destroyed by fire on December 14, with loss said to be about $100,000.

NEWCASTLE.—Fire on December 6 destroyed a section of the plant of the Wilmington Fibre Specialties Company, which was engaged on Government contracts. The loss is estimated at $300,000.

NEWCASTLE.—Fire on December 12 destroyed a portion of the shell-loading plant of the Bethlehem Steel Company, near Newcastle, with loss estimated at about $100,000.

NEWCASTLE.—The Penn-Seaboard Steel Corporation has acquired property adjoining its Baldt works, about 85 acres, and is said to be planning for the construction of a new steel plant.

Florida

JACKSONVILLE.—The Vulcan Iron Works has acquired property on East Bay Street, for a consideration of about $10,000, and is planning for the construction of a large new plant.

Illinois

CHICAGO.—The Nubian Paint & Varnish Company, LeClaire Avenue, has acquired property adjacent to its works, and is planning for the erection of additions to provide for increased capacity. The property was purchased for a consideration of $25,000.

CHICAGO.—Swift & Company has completed arrangements for the purchase of a tract of 26,175 acres of land in West Hammond, and is having plans prepared for the construction of a new fertilizing plant to comprise a group of one-story concrete and brick structures. The entire works, when completed, are estimated to cost about $500,000.

ROCKFORD.—The Rockford Milling Machinery Company is making rapid progress in the construction of a new two-story addition, about 35 x 120 feet, at Harrison Avenue and Eleventh Street, to cost about $25,000.

E. ST. LOUIS.—The Excelsior Tool & Machine Co. is extending its plant and adding to its foundry. New pattern storage and pattern shop buildings will also be erected. A large core oven and ten-ton and two-ton cranes will be required.

Indiana

LAFAYETTE.—The Barnhard Fertilizer Company, recently incorporated at Frankfort with a capital stock of $100,000, has acquired the plant and business of William Kalberer, 906 Sycamore Street, and is planning for extensive improvements and alterations. The consideration was $15,000. S. L. Barnhard is president of the company.

GREENCASTLE.—The American Zinc Products Company, which recently purchased the old Western Tin Plate Mill, has acquired 60 acres of land adjoining the works and is planning for the construction of a new ten-mill plant. The works will give employment to about 500 hands.

MUNCIE.—The Standard Oil Company has acquired property on West Charles Street, and is having plans prepared for the construction of a new three-story brick plant.

Louisiana

CONVENT.—Fire recently destroyed the sugar manufacturing plant of the Louis Himel Planting & Manufacturing Company at its Elyisa plantation, with loss estimated at $100,000.

Maine

PORTLAND.—The Berlin Mills Company has announced that arrangements have been perfected for its consolidation with the Burgess Sulphite Fiber Company, the new organization to be known as the Brown Company. It is planned to increase the capacity of its paper and paper products mills. H. J. Brown is president.

Maryland

BALTIMORE.—Fire recently destroyed a portion of the Mount Winans works of the Maryland Glass Manufacturing Company. It is said the damaged section will be immediately rebuilt.

Massachusetts

BOSTON.—Contract has been awarded by F. E. Atteaux & Company, manufacturers of chemicals, dyestuffs, etc., for the erection of a new two-story reinforced-concrete factory building, about 65 x 170 feet, in South Boston. The Turner Construction Company, Boston, is the contractor.

Michigan

MENOMINEE.—The Menominee Electric Manufacturing Company is taking bids for the erection of four one-story additions to its works to cost about $60,000.

MUSKEGON.—Rapid progress is being made in the construction of the new plant of the Muskegon Aluminum Foundry Company, Clay Avenue and Ninth Street, and it is expected that the works will be ready for the installation of machinery and equipment within the next three weeks. A. E. Johnson heads the company.

Missouri

ST. LOUIS.—The Pontiac Iron & Land Company is planning for the erection of a pig iron furnace with initial capacity of 40 tons, on property recently acquired in Wayne County. The company owns a tract of about 20,000 acres in this district and plans for extensive operations. J. F. Lindsay, St. Louis; Ira J. Hoover, Waterloo, Ia., and C. H. Plant, San Antonio, Tex., head the company.

ST. LOUIS.—Fire recently destroyed a portion of the plant of the Liquid Carbonic Company, 3400 Bernard Street, with loss estimated at $50,000.

New Jersey

JERSEY CITY.—The Interstate Chemical Company, 657 Garfield Avenue, manufacturer of chemicals and allied products, has taken out a building permit for the construction of a new addition to its plant at 673 Garfield Avenue.

HARRISON.—The E. I. duPont de Nemours Company has announced that effective January 1, 1918, it will discontinue the sale of acids and chemical products of its Harrison works through the National Oil & Supply Company, and will establish a branch for this purpose at 272-78 Passaic Street, Newark.

NEWARK.—The Block Chemical Works has acquired the property of the Berkeley Brick Company, Berkeley Heights, N. J., for a consideration said to be $25,000, and is planning to use the works as an addition to its plant.

NEWARK.—The United Color & Pigment Company is having plans prepared for the construction of a new three-story brick factory and a new one-story brick power house, to cost $54,212 and $10,572, respectively. Percy B. Taylor, Essex Building, is the engineer.

MORRISTOWN.—Charles Butters, of Oakland, Cal., has acquired property consisting of 10 acres at the junction of the Morristown & Erie Railroad and the Malapardis branch, and is planning to commence work immediately on the erection of a new aluminum bronze works.

JERSEY CITY.—The Air Reduction Company has taken out a building permit for the erection of a new one-story steel factory addition to its plant at 171 Pacific Avenue.

BAYONNE.—The Southern Cotton Seed Oil Company, East Twenty-second Street, has had plans prepared for alterations and extensions in its plant to cost about $8,000.

CAMDEN.—Wilckes, Martin & Wilckes Company, 135 Williams Street, manufacturer of chemicals, has awarded a contract for the construction of two new additions to its plant, one and two-story, about 110 x 134 and 30 x 100 feet, respectively. J. H. O'Leary, 500 Bloomfield Avenue, Passaic, is the contractor.

IRVINGTON (NEWARK).—The Irvington Varnish and Insulator Company, 218-232 East Speedway Avenue, has taken out a building permit for the erection of a new one-story brick factory, to cost about $25,000.

NEWARK.—The Block Chemical Works of Newark, N. J., has purchased the Berkeley Brick Company plant, located on the Lackawanna Railroad, at Berkeley Heights, N. J. The principal building is 36 x 308 of brick, steel and concrete construction with a large stack. The purchase was made through the Factory Exchange of New York. The Block Chemical Works is to completely equip this plant and not only require steam-producing machinery, but must provide for their private water supply and the apparatus necessary to produce their chemicals. We understand that their principal product is to be barium chloride.

NEWARK.—The Butterworth-Judson Company, Avenue R, manufacturer of chemicals, is planning for the erection of two new additions to its plant, about 50 x 55 feet, one-story, to cost $10,000, and a one-story machine and pipe shop, 50 x 90 feet, to cost $8,000.

NEWARK.—The Eclipse Tanning Company, 119 Sussex Avenue, is having plans prepared for the construction of a new factory building, about 100 x 200 feet, on the southwest corner of Sussex Avenue and Day Street. The structure will cost about $22,000.

ROOSEVELT.—Fire, on December 4, completely destroyed the nitric acid department of the Armour Fertilizer Works, with loss estimated at about $20,000. The destroyed portion of the plant will be immediately rebuilt.

SOUTH RIVER.—Fire recently destroyed the plant of the Para Products Company, manufacturer of rubber goods. The destroyed structure was about 100 x 200 feet, and it is said that chemicals used in the manufacture of the company's products were the cause of the blaze.

TRENTON.—The Joseph Stokes Rubber Company, Taylor Street, has awarded a contract to Edward LaRue, 52 South Hermitage Street, for the erection of a one-story addition to its plant.

TRENTON.—The National Carbon Company, 26 West State Street, has filed notice of the dissolution of the company.

Virginia

ALEXANDRIA.—The United States Government, Department of Agriculture, has awarded a contract for the construction of an addition to its chemical laboratory at Arlington Farm, near Rosslyn. Estimated cost of the structure will be $13,800.

New York

PORT RICHMOND, S. I.—The Standard Oil Company has acquired property on Richmond Avenue, adjoining its plant, and is planning for the erection of additions to provide for increased capacity.

LAUREL HILL, L. I.—The General Chemical Company, Washington Avenue, has awarded a contract for the construction of a new one-story addition to its local laboratory, to cost about $8,000. Leddy & Moore, 105 West Fortieth Street, New York, are the contractors.

YONKERS—The National Sugar Refining Company, Main Street, has filed plans for the construction of a new one-story brick addition to its plant, about 44 x 50 feet.

ROCHESTER.—A new one-story concrete and steel foundry addition, about 72 x 80 feet, will be erected by the Gleason Works, University Avenue. The company has taken out a building permit for the structure, which is estimated to cost $12,000.

BUFFALO.—The National Aniline & Chemical Company, Lee Street, is planning for the immediate construction of a new three-story brick factory building to cost $88,500.

North Carolina

JAMESTOWN.—The Caroline Pyrites Ore Company, recently organized with a capital of $100,000, is planning for the operation of its proposed new works at Gardner Hill. The machinery and equipment installation is estimated to cost $75,000.

Ohio

CARTHAGE.—The Pollak Steel Company has had plans prepared for the construction of two new additions to its plant, comprising a one-story foundry building, about 200 x 300 feet, and new drafting building. Contract for the latter structure has been awarded to the M. Marcus Building Company, Carthage.

MARIETTA—The Nye Foundry Company has completed arrangements for the removal of its foundry to West Spring Street, Columbus, Ohio, and is planning to double the capacity of the present plant. About 200 hands will be employed at the new location. B. H. Nye is general manager of the company.

SANDUSKY—The American Crayon Company is considering the acquirement of 10 acres of land in the extreme southeast corner of the city, as a site for its proposed new picric acid plant.

WARREN—M. A. Garvey and L. J. Garvey, Sharon, are planning for the establishment of a brass foundry in the old Day-Ward plant on North Park Avenue. It is the intention of the company to construct a plant of its own on property now under consideration. M. A. Garvey is manager.

Oklahoma

BARTLESVILLE—The United States Government has announced that the Bureau of Mines is planning for the construction of one of its experimental stations for the investigation of problems relating to the petroleum and natural gas industries, on a local site.

Pennsylvania

HEIDELBERG—Fire recently destroyed a portion of the plant of the Ætna Chemical Company at Heidelberg, near Pittsburgh, with loss estimated at $250,000. The fire was caused by an explosion, the plant being engaged in the manufacture of T.N.T.

KITTANNING.—Plans are being made by the Carbon Steel Company for the erection of two open-hearth furnaces on a site now under consideration, each furnace to have a capacity of about 100 tons of pig billets daily. This company recently acquired the property of the Kittanning Iron & Steel Company.

LEBANON—The Lebanon Blast Furnaces, operated by the E. J. Lavino Company, have suspended operations for relining and improvements, and it is expected that the work will be completed by the first of the year. These furnaces are devoted to the production of ferromanganese.

PHILADELPHIA—The Gorgas-Pierre Manufacturing Company, 144 East Allen Street, manufacturer of oils, etc., has awarded a contract for the construction of a new three-story concrete addition to its plant, about 75 x 156 feet to cost $50,000. The Turner Concrete Steel Company, 1713 Sansom Street, Philadelphia, is the contractor.

PITTSBURGH—Extensive alterations and improvements are being made in the plant of M. Streng's Sons Company, 1306-46 River Avenue, and the company is also planning for the construction of a new addition in which furnaces will be installed for the reclaiming of metals.

CANONSBURG—E. W. Edwards and associates, Cincinnati, Ohio, have taken over the plant of the Canonsburg Steel & Iron Works, and are planning for extensive additions to increase the capacity. The consideration is to be about $600,000.

MONONGAHELA CITY—The Monongahela Steel & Iron Company is perfecting arrangements for the construction of a new 36-furnace plant in Paden City, W. Va. Thomas Watson, Pittsburgh, is secretary and treasurer for the company.

ST. MARY'S—The Speer Carbon Company and the Stackpole Carbon Company are each installing two branches with vertical retorts for calcining petroleum coke. The Russell Engineering Company of St. Louis is making the installations.

Tennessee

KNOXVILLE—Construction of extensive additions to the plant of W. J. Oliver Company are being rushed to completion. New machinery has been ordered and will cost about $250,000. The plant is specializing in the production of six-inch shells for the Government, and will have a capacity of 1500 shells daily.

NASHVILLE—It has been reported that the du Ponts are planning the establishment of a million dollar explosive plant near Nashville. 2500 acres having been bought for a site. The report has not been verified by the du Pont Co.

Texas

BROWNWOOD.—The Gotebo Oil & Refining Company has commenced the construction of a large new local refinery on a site just south of the city. It is expected that the first unit of the plan will be completed and ready for operation within thirty days.

Utah

HONEYVILLE.—The Utah-Idaho Sugar Company has acquired a tract of 120 acres of land and is reported to be planning for the construction of a large new sugar plant.

SALT LAKE CITY.—The Utah Oil Refining Company is planning for the construction of extensive additions to its plant, to include a new paraffine works to cost $50,000; new tank to have a capacity of 1,500,000 gal, to cost $35,000, and the doubling of the present capacity of the power house. Headquarters of the company are at Fourth Street West and Ninth Street North. J. C. Howard is general manager.

SALT LAKE CITY—The Cedar Butte Oil Company is having plans prepared for the erection of a large reduction plant at its oil properties at Whiterocks.

Washington

SEATTLE.—The Alaska Gastineau Mining Company, Juneau, Alaska, has announced that a large new steel plant will be constructed on the Puget Sound which will involve an expenditure of approximately $25,000,000. The first unit of the plant will require an investment of $9,000,000, and work will be started on the plant within 90 days. Mr. Bart L. Thane is general manager of the company. W. H. Crocker, H. Fleischhacker, and S. F. B. Morse, San Francisco, Cal., are also interested in the project.

SEATTLE.—The Seattle Smelting Co., Inc., has completed its plant and is now producing ferromanganese. One three-phase unit capable of producing six tons of alloy per day has been installed and others ordered. Other ferroalloys may be produced later.

West Virginia

WHEELING.—The Superior Glass Manufacturing Company has recently completed the erection of a new addition to its plant to provide for increased capacity. The works were formerly occupied by the Haskins Glass Company, and when acquired by the Superior company, extensive improvements were made.

HUNTINGTON.—The Huntington Steel Products Company, specializing in the manufacture of munitions, is planning to increase the capacity of its plant.

HUNTINGTON.—L. H. DePaul, Foxboro, Mass., and associates are considering the erection of a large new local chemical plant, to be devoted to the manufacture of salycilic acid from sawdust.

Wisconsin

MADISON.—Fire recently destroyed a portion of the plant of the Southern Foundry Company with loss estimated at $50,000. The company was engaged in the manufacture of materials for munition plants.

MILWAUKEE.—The George H. Smith Steel Casting Company, 500 Clinton Street, is making rapid progress in the construction of a large new addition to its foundry.

MILWAUKEE.—The new plant of the General Steel Company near lake shore has commenced partial operations. The works consist of a large machine shop, mill building, storage building, and smaller shop structures, and the remainder of the machinery is now being installed. It is expected that the plant will run at full capacity within thirty days. The product of the works will be a high-grade electric steel. Harry Weidenthal is superintendent.

Manufacturers' Catalogs

E. I. DUPONT DE NEMOURS & COMPANY, together with its associates—the DuPont Fabrikoid Co., DuPont Chemical Works, the Arlington Company and Harrisons, Inc.—have issued a new products book, listing all the products of the above concerns and describing their uses. The head offices of the company are at Wilmington, Del.

THE BARRETT COMPANY, 17 Battery Place, New York City, has issued a new booklet on the source, production and use of sulphate of ammonia.

TATE-JONES & COMPANY, Pittsburgh, Pa., has issued Bulletin No. 160, giving a complete description of its recuperative gas-oven furnaces for the heat-treatment of steel.

CONDENSITE COMPANY OF AMERICA Bloomfield, N. J., has issued a new booklet, describing its various molding preparations and other phenolic condensation products.

LINK BELT COMPANY, Chicago, Ill., has issued a new bulletin entitled "The Ideal Drive for Clay Working Machines," giving many illustrations of the uses of link belts.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, East Pittsburgh, Pa., has issued Catalog 30, covering the company's complete line of direct-current motors and generators for industrial service.

Other New Publications

DETERMINATION OF MOISTURE IN COKE. A. C. Fieldner and W. A. Selvig. A bureau of mines technical paper, No. 148. Obtainable from the Bureau of Mines, Washington, D. C.

GOLD, SILVER, COPPER AND LEAD IN SOUTH DAKOTA AND WYOMING, in 1916. By Charles W. Henderson. U. S. Geological Survey report obtainable from the U. S. Geological Survey, Washington, D. C.

ANNUAL REPORT OF DIRECTOR OF BUREAU OF MINES, for year ending June, 1917, issued by Bureau of Mines, Washington, D. C.

Manufacturers' Notes

THE AMERICAN CHEMICAL & OZOKERITE Co. has removed its Chicago offices to 7323 Woodlawn Avenue, where the manufacturing plant is located.

THE RAYMOND BROS. IMPACT PULVERIZER Co., of Chicago has appointed the Dry Milling Engineering Co., 202 Boston Building, Denver, Col., western agents for its pulverizing machinery. The latter concern is headed by William B. Senseman and it will also represent the Buckeye Dryer Co., London, Ohio, the Dust Recovering & Conveying Co. of Cleveland and the Quigley Furnace Specialties Co. of New York. Mr. Senseman has been connected with Raymond Bros. for the past eight years. The Dry Milling Engineering Co. is a newly incorporated concern.

THE JONATHAN BARTLEY CRUCIBLE CO. of Trenton, N. J., manufacturers of crucibles and retorts, has engaged F. P. Welton of Stamford, Conn., to represent them in New England and Canada.

THE DIAMOND POWER SPECIALTY COMPANY of Detroit, Mich., is planning to market on a large scale a calorized metal known as Insuluminum, a description of which was given in our issue of Oct. 15, 1916, p. 498. A large plant has been built for its manufacture for such uses as soot blowers, superheater tubes, carbonizing boxes, annealing boxes, etc.

GANNESTAD & JACOBSEN, engineers, have moved their Pittsburgh headquarters to the B. F. Jones Building, where larger quarters are available. The firm is engaged in the designing of iron and steel and other industrial plants and special machinery.

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Outlook for Water-Power Legislation

IN his message to the Congress last December the President said:

> "It is imperatively necessary that the consideration of the full use of the water power of the country * * * should be immediately resumed and affirmatively dealt with at the earliest possible moment. The pressing need of such legislation is daily becoming more obvious."

By emphasizing the "full use of the water power of the country" and the "pressing need" which is "daily becoming more obvious," the President shows his appreciation of the fair demands of all sections of the country and condemns the delay in legislation which has brought us to a state of pressing need for power. The government, being temporarily in the business of waging war, is suddenly brought to a realization of a condition which industry and private business have long since recognized.

Aside from Niagara and other projects that might be developed on boundary streams, which must be dealt with by international treaty, there are internal sources of water power subject only to our own legislation. These are upon navigable streams, public lands and national forest reserves. By our system of national organization the control of these three sources is vested in three separate departments of the government, viz., War, Interior and Agriculture respectively. This in itself is a complication that has proved a formidable barrier to progress in federal legislation, for hitherto it has seemed necessary to initiate special bills for each department in both houses of Congress.

It may be considered a stroke of policy, therefore, on the part of the Administration to attempt to surmount past obstacles by introducing in the House a new bill which has been drafted under the direction of the Secretaries of War, Interior and Agriculture covering all internal water power development, and which they consider most "likely to secure extensive devlopment of this resource." A digest of this new measure is given on another page in this issue. The bill embodies the fundamental features of several bills previously introduced in Congress, and aims to avoid their defects. In this it is largely successful, although a few moot points will have to be settled before the bill is passed if it is to be productive of actual development.

The term "actual cost" is used without definition in that section of the bill which provides for the taking over by the government of any project at the expiration of the term of license. Unless this term is clearly and satisfactorily defined, it would be fruitful of controversy in the transfer of any project from the licensee to the government. Indeed, failure to define the term would defeat the purpose of the bill, for prospective licensees would not be inclined to invest in a project the

value of which is to be determined only by future agreement between the Federal Power Commission and the licensee, or by proceedings in equity in a federal district court. Other provisions of the bill which probably will be modified relate to the issuance of new licenses at the end of a fifty-year period, and to the possible confusion in federal and state regulation of the licensee's securities, rates and service. It is practically assured that the bill will pass the House almost without debate. At this writing no such certainty exists with respect to the Senate, but it is more than likely that that body will fall in with the Administration's plan.

It will be a matter for congratulation if Congress shall act intelligently and quickly in this matter. Surely that body of men must have shared with the rest of us the feeling of impotence in our recent coal shortage and transportation difficulty, most of which would not have existed if we had long since developed our water powers. No more striking example should be needed of the folly of using coal so extensively for lighting, transportation and power—exhausting a resource which can serve us but once and neglecting another that is inexhaustible. Our lack of extensive hydro-electric development has made necessary the employment of much labor and rolling stock in the mining and transportation of coal. Most of this labor could have been released for productive work in other industries, and the rolling stock would have been available for transporting food, munitions and supplies, if we had been foresighted enough to develop a resource just at hand. We should have been in worse straits but for the projects already developed in the West which are supplying railroads, mines and cities with power. Dozens of undeveloped sources of water power still remain in the West and in other parts of the country, placing on us the duty of exerting every legitimate effort to see that Congress does not fail the nation at this critical time.

Analyzing for Traces

IT is doubtless a truism to remark that when a scientist digs deeper into the unknown, he little knows the infinite possibilities of the knowledge he uncovers. By that same token, works' chemists and metallurgists will cordially welcome the acquaintance of a new branch of so-called "pure science," namely, "the spectroscopy of the ultra-violet." In this wise:

Many modern chemical and metallurgical products are pure—containing smaller impurities than the familiar "chemically pure" reagents—and are shipped as such in enormous quantities. The final processes in the refining of such materials demand intermediates, solutions, or melts of extraordinary purity, and of course the chemical control requires most precise analysis for minute traces of foreign bodies.

In the remelting of copper wire and scrap, the bath must be worked until the lead, introduced by pieces of lead-covered cable, is below a certain small fraction, depending upon the ultimate use of the copper. Or, take as another instance, the zinc sulphate solution from which electrolytic zinc is precipitated. This solution must be free of cadmium, iron and copper (among other elements), not nearly free, but really free. Since it takes an expert analyst about three days to make a cadmium determination, in the meantime the electrolyte has been electrolyzed! Not only this, but few chemists who are skillful enough or reagents which are pure enough to analyze for traces are available in war times.

Messrs. Hill and Luckey presented a paper before the last American Electrochemical Society meeting (METALLURGICAL AND CHEMICAL ENGINEERING, Dec. 1, 1917, page 659) showing how a spectrograph can be used for quick determinations of traces of lead in a copper bath, which analysis is necessary in the first instance cited above. The spectrum has also been adapted for the determination of coloring matter in wines, the detection of blighted wheat flour, nitrates in water, phosphorus in suspected poisoning, and in the analysis of sugar and essential oils.

These instances are only an indication of the future usefulness of the method. While qualitative spectrum analysis is familiar to elementary students, quantitative spectrum analysis is a comparative stranger to experts, and seems to be confined to the determination of very small amounts of material—less than ten parts per million. That is exactly what is required in many metallurgical and chemical processes, and further intensive research along this line will undoubtedly prove to be very stimulating and highly productive of badly needed "short cuts."

The Present and Future of Potash

A TRITE expression that has gained currency in recent months informs us that any one of a dozen or so commodities "will win the war." The range is wide—from sugar to coal, wool to sulphuric acid. The expression has lost much of its earlier force, and the idea which it conveys has become as preposterous as the thought that the war can be won by the simple expedient of "doing our bit." Both expressions should be dropped from our war vocabulary, because the facts are that no single commodity will win the war, and we are only deceiving ourselves if we think that "our bit," or anything short of our all, will be sufficient.

All this is parenthetical to a brief consideration of potash as a war mineral, which, if it will not "win the war," is nevertheless of vast economic importance. Practically all the potash used in this country has normally come from Germany. The elimination of that supply threw us upon our own resources to meet pressing needs. Accordingly we took stock of the possibilities, and produced potash from natural brines, alunite and silicate rocks, cement-kiln and blast-furnace dust, kelp, wood ashes, beet and cane molasses, and distillery waste. In other words, we have made every possible source yield some potash, although much of the present industry is on strictly a war basis, and probably cannot continue in normal times.

Natural brines have been the most productive of all domestic sources. Alkali lakes in western Nebraska have been made to support a large industry, recently described in this journal. This development may not be able to survive a return to normal conditions, although the prospects will be better if methods of operation are improved. Searles Lake, in California, on the other hand, bids fair to be a real factor in supplying a large part of our needs. But whatever the future of potash from brines, it is certain that these lakes afforded the most readily available supply in our emergency.

The extraction of potash from silicate rock has been

an attractive proposition on account of the abundance of the material. Potash forms nearly 3 per cent of the earth's crust, and there are several silicate rocks containing the compound to the extent of 10 to 15 per cent. But if the material is abundant it is also chemically combined in such form as to be difficult of extraction, so that actual production from this source has lagged; this, too, in spite of a vast amount of research and experimentation, as indicated in the bibliography we are now publishing. So abundant and widely distributed a resource, however, is not likely to remain unutilized, and it seems reasonable to contemplate the possibility of supplying therefrom a large part of the world's demand for potash. With this in prospect, the reader will find some impressive figures in the interesting article in this issue contributed by Mr. Washington, who tells the potash story of Italian volcanoes.

Recovery of potash from kelp, a seaweed of common growth along our Southern Pacific coast, is likewise a most interesting problem. In the past few years we have developed an industry in California in which the investment aggregates between three and four million dollars. This is a large investment in a business which, frankly, will not be profitable after the war if German potash is again imported at pre-war prices. If the war continues long enough, the cost of plants can be amortized and the business abandoned when competition again exists. But this is not a pleasant prospect; we would far rather see the industry firmly established on a sound technical basis and able to hold its own. One difficulty at present is that none of the operators is willing to conduct any research. They feel that it is their business to make potash while they can, at present prices, because they know the precarious nature of their industry. This is all right for the present, but not satisfactory for the future. Hence the greatest importance attaches to the government experimental kelp farm on the California coast, where the problems are being attacked in a scientific manner by the Department of Agriculture with an eye to the future stability of the industry. The chief problems are those of drying and distillation, coupled with recovery of all possible by-products from the latter process, such as tar, ammonia and combustible gases. The object of the farm and plant is to determine whether potash can be produced from kelp at a profit or loss. The results will give a fairly definite answer to the question of the importance of kelp as a source of potash after the war.

Restricted Steel Output

IT makes a poor showing indeed that the steel ingot production of the United States in 1917 was only about 42,000,000 tons, as just estimated by the American Iron and Steel Institute, against 41,400,000 tons produced in 1916, for there was new open-hearth steel-making capacity completed in 1916 to the extent of fully 4,000,000 tons, and a like amount of new capacity was added in 1917. As new construction began, and in only a very humble way, in June, 1915, the 1916 new capacity must have come in chiefly toward the latter part of the year, while the new construction in 1917 cannot have fallen preponderatingly toward the close of the year. Hence, with full operation of existing capacity throughout both years, the increase from one calendar year to the next should have been in excess of 4,000,000 tons, instead of only 800,000 tons.

The restriction in steel ingot output in 1917 was due chiefly to a shortage of pig iron. Whether under the most favorable operating conditions at the blast furnaces they could have produced enough pig iron to supply all the steel-making capacity is a question. What is well known is that the blast furnaces did not operate at capacity in 1917. Pig-iron production was about 800,000 tons less than in 1916, whereas there was much more capacity. From May 13, 1916, to the end of the year four new blast furnaces were blown in, and in 1917 there were 14 new blast furnaces completed, largely about the middle of the year, the 18 stacks being fully equal to a production of 2,000,000 tons of pig iron a year.

While it may be true that if the chief bar to full production of pig iron in 1917 had not existed various other minor influences might have been felt, the outstanding fact is that pig-iron production in 1917 was held at the low level shown because not enough coke was moved from the Connellsville coke region to the blast furnaces depending on the region. There was a decrease in that movement, from 1916 to 1917, of nearly 4,000,000 tons. As to the cause, there was much "passing the buck" during the year, chiefly between the operators and the railroads. The operators claimed car supplies were insufficient, the railroads rejoining that when more cars were furnished they were not loaded, whereupon the coke operators came back and asserted that in periods of enforced idleness their labor drifted away. Toward the close of the year they claimed they had much more labor than formerly, but car supplies were still poorer. Obviously a condition existed which required team work, and the United States Government has become the "big boss." At the end of the old year it took over the operation of the railroads and on Jan. 3 Warren S. Blauvelt, national coke administrator, addressed the coke operators of the Connellsville region at Uniontown, assuring them that full transportation facilities would be provided and insisting that there must be full production of coke or something would be done by Washington.

What is particularly distressing in the situation is that the deficit in coke supply, particularly as regards the conditions of the past few months, is less than the amount by which Connellsville coke shipments have decreased. If the region were shipping as much coke as in 1916 there would be a surplus of coke. The completion of by-product ovens has been such as to take care of the increase in blast furnace capacity.

It is to be hoped that relief as to supplies of Connellsville coke will be afforded very shortly. In another direction a measure of relief of no small consequence will be provided, as the by-product plant of 640 ovens at Clairton is nearing completion and may make its first coke by April 1, with full production of the 640 retorts not long afterward. Their expected output is 2,740,000 tons of coke a year, on the conservative estimate of a 67 per cent yield, with nearly 7000 cu. ft. of gas per ton of coke made, the gas in turn doing its bit to relieve the fuel situation, for all the coal consumed at the Clairton plant will be brought by water. As the coke will be distributed to the various blast furnaces by the Carnegie Steel Company's own interplant road the entire operation will be independent of the railroads.

Readers' Views and Comments

Mill Pumping Systems: Frenier Pump Capacities

To the Editor of Metallurgical & Chemical Engineering

SIR:—I regret that, through an error in typing, the Frenier pump capacities appearing in your Dec. 1 issue were underestimated by the omission of the final "0" in each case. The table should have read:

Size, Inches	Specific Gravity of Fluid					
	1.000	1.100	1.200	1.300	1.400	1.500
	Tons per 24 Hours					
44 by 6 48 by 6 54 by 6	450	490	540	580	630	670
44 by 8 48 by 8 54 by 8	540	590	650	700	760	810
44 by 10 48 by 10 54 by 10	630	690	760	820	880	940

These capacities are based on moderate lifts, precise adjustment and maintenance of level of liquid in the box, and free discharge. If any one of these conditions is impracticable the figures should be reduced accordingly.

A. W. ALLEN.

Denver, Colo.

Conversion Table: Pounds to Grams

To the Editor of Metallurgical & Chemical Engineering

SIR:—The accompanying table will serve as a convenient means of rapidly converting pounds avoirdupois into grams. The facility with which this operation may be performed will be quite apparent, but the following description will not be out of place:

In Table I, pounds avoirdupois (1 to 9) are indicated by figures in left-hand column. The metric units are indicated by headings along the upper border. One pound (avoirdupois) equals 453.5924 grams, or 45.359 decograms, or 453592.4277 milligrams.

TABLE I

POUNDS	GRAMS												
		KILOGRAMS	HECTOGRAMS	DECOGRAMS	GRAMS	DECIGRAMS	CENTIGRAMS	MILLIGRAMS					
1	0	0	4	5	3	5	9	2	4	2	7	7	
2	0	0	9	0	7	. 1	8	4	8	5	5	4	
3	0	1	3	6	0	. 7	7	7	2	8	3	1	
4	0	1	8	1	4	3	6	9	7	1	0	8	
5	0	2	2	6	7	. 9	6	2	1	3	8	5	
6	0	2	7	2	1	. 5	5	4	5	6	6	2	
7	0	3	1	7	5	. 1	4	6	9	9	3	9	
8	0	3	6	2	8	. 7	3	9	4	2	1	6	
9	0	4	0	8	2	3	3	1	8	4	9	3	
POUNDS	TEN-THOUSANDTHS	THOUSANDTHS	HUNDREDTHS	TENTHS	UNITS	TENS	HUNDREDS	THOUSANDS	TEN-THOUSANDS	HUNDRED-THOUSANDS	MILLIONS		

TABLE II—VALUE OF DECIMAL PARTS OF A POUND IN GRAMS

Oz.	Parts	Value	Oz.	Parts	Value	Oz.	Parts	Value
	.01	4.535 924		.35	158.757 350	11		311.844 794
	.02	9.071 849		.36	163.293 274		.69	312.978 775
	.03	13.607 773		.37	167 829 198		.7	317.514 699
	.04	18.143 697	6		170.097 160		.71	322.050 624
	.05	22.679 621		.38	172.365 123		.72	326.586 548
	.06	27.215 546		.39	176.901 047		.73	331.122 472
1	.0625	28.349 627		.4	181.436 971		.74	335.658 396
	.07	31.751 470		.41	185.972 895	12	.75	340.194 321
	.08	36.287 394		.42	190.508 820		.76	344.730 245
	.09	40.823 318	7		198.446 687		.77	349.266 169
	.1	45.359 243		.43	195.044 744		.78	353.802 094
	.11	49.895 167		.44	199 580 668		.79	358.338 018
	.12	54.431 091		.45	204.116 592		.8	362.873 942
2	.125	56.699 053		.46	208.652 517		.81	367.409 866
	.13	58.967 016		.47	213 188 441	13		368.543 847
	.14	63.502 940		.48	217.724 365		.82	371.945 791
	.15	68.038 864		.49	222.260 290		.83	376.481 715
	.16	72.574 788	8	.5	226.796 214		.84	381.017 639
	.17	77.110 713		.51	231.332 138		.85	385.553 564
	.18	81.646 637		.52	235.868 062		.86	390.089 488
3	.1875	85.048 580		.53	240.403 987	14		396.893 374
	.19	86.182 561		.54	244.939 911		.87	394.625 412
	.2	90.718 486		.55	249.475 835		.88	399.161 336
	.21	95.254 410		.56	254.011 760		.89	403.697 261
	.22	99.790 334	9		255.145 741		.9	408.233 185
	.23	104.326 258		.57	258.547 684		.91	412.769 109
	.24	108.862 183		.58	263.083 608		.92	417.305 033
4	.25	113.398 107		.59	267.619 532		.93	421.840 958
	.26	117.934 031		.6	272.155 457	15		425.242 901
	.27	122.469 955		.61	276.691 381		.94	426.376 882
	.28	127.005 880		.62	281.227 305		.95	430.912 806
	.29	131.541 804	10		283.495 267		.96	435.448 731
	.3	136.077 728		.63	285.763 229		.97	439.984 655
	.31	140.613 653		.64	290 299 154		.98	444.520 579
5		141 747 634		.65	294.835 078		.99	449.056 503
	.32	145.149 576		.66	299.371 002	16	1.	453.592 428
	.33	149.685 501		.67	303.906 927			
	.34	154.221 425		.68	308.442 851			

Along the lower border are indicated the numerical denominations, located in a manner that permits them to be used as multipliers or divisors for the pound unit values.

As an example, it is desired to know the value of 5.5 pounds in grams.

From the value opposite the index figure 5 read 2267.9621385, and then it is quite obvious that .5 would be one-tenth of the above amount, or

5. lb. = 2267.9621385 g.
.5 lb. = 226.79621385 g.

5.5 lb. = 2494.75835235 g.

Table II will serve the purpose of representing the value of decimal parts of a pound avoirdupois, varying by one-hundredths.

The value of 5.5 pounds in grams may be read direct from the table by shifting the decimals in the value opposite .55 pounds.

It will also be noted that the exact decimals representing the ounces in a pound are shown in the column of figures headed "Oz."

DWIGHT GERBER.

Pittsburgh Terminal Railroad & Coal Co.,
Pittsburgh, Pa.

Determination of Phosphorus in High-Speed Steels

To the Editor of Metallurgical & Chemical Engineering

SIR:—The writer has the issues of METALLURGICAL & CHEMICAL ENGINEERING for Feb. 1, Dec. 1 and Dec. 15, 1917, before him, open respectively to the contribution of Mr. E. C. Kraus concerning determination of phosphorus in high-speed steels, the writer's comments thereon, and Mr. Kraus' reply to the writer.

From Mr. Kraus' own statement the vital points in his contribution are two in number. First, the elimination of tungsten without evaporation and subsequent "baking," and second, the elimination of interference of vanadium in the precipitation of phosphorus by reduction with sulphurous acid.

Regarding these two significant points of his contribution, it is common knowledge that WO_3 does not require "baking" to render it insoluble in an aqua regia solution, and that "baking" is resorted to only when silicon is to be determined, as well as tungsten and phosphorus, from the same sample-weight. Obviously, then, the only point for which credit could be claimed was the elimination of the interference of vanadium.

The contention of the writer in his comment appearing in the Dec. 1 issue of METALLURGICAL & CHEMICAL ENGINEERING was that credit for this time-saving procedure should go to two Bureau of Standards chemists. In looking over his files to ascertain the names of these chemists, the writer finds that he was in error when he stated that the article concerning investigations in the precipitation of phosphorus in the presence of vanadium appeared in METALLURGICAL & CHEMICAL ENGINEERING in 1913. The publication to which the writer had reference was *Technological Paper* No. 24 of the Bureau of Standards, written by J. R. Cain and F. H. Tucker, published May 17, 1913. The use of sulphurous acid in eliminating interference of vanadium in this determination is also incorporated in Standard Methods of Analysis as given in A. S. T. M. Year-book for 1915. Both of these publications antedate considerably Mr. Kraus' communication. The writer merely worked out the application of the procedure, as outlined by J. R. Cain and F. H. Tucker, to the method then in use, involving the separation of tungsten as a necessary preliminary to the determination of phosphorus.

Plattsburg, N. Y. W. T. SHEFFIELD.

* * *

To the Editor of Metallurgical & Chemical Engineering

SIR:—As I am somewhat interested in the recent discussion regarding the determination of phosphorus in high-speed steel, by W. T. Sheffield and E. C. Kraus, I wish to corroborate Mr. Sheffield's statement that his method was worked out in this laboratory during the fall of 1913.

While talking with Mr. Kraus last summer concerning his method I do not remember having made reference to a similar method of previous origin—a fact which I unintentionally omitted. However, we had been using Mr. Sheffield's method in this laboratory for some time before the article by Mr. Kraus was published. The sole purpose of this letter is to corroborate Mr. Sheffield's dates. O. L. VAN VALKENBURGH.

Crucible Steel Company of America,
Sanderson Bros. Works,
Syracuse, N. Y.

The pertinent facts being established, the discussion is closed.
—EDITOR.

Power from Coal

To the Editor of Metallurgical & Chemical Engineering

SIR:—I was very much interested in the article regarding power from coal, which was published under Readers' Views and Comments in your issue of December 1, 1917. The demand for power is beginning to exceed the supply, and every effort must be put forth to obtain it. When a condition of this kind occurs results may be expected in improving the efficiency of apparatus used for power generation.

With the present steam plants little more efficiency can be expected, except in the smaller plants. It is generally true that the small plant, up to 5,000 kw., as a rule, operates inefficiently. Much is being done to improve this, and it is probable that the next year will see great improvements in the average small plant. Increase of pressure and superheat over the existing standards, for these are more or less standard, will result in improvements in efficiencies of probably 10 to 12 per cent. The difficulties are more of a practical nature than otherwise, but the turbine and boiler builders are ready to make any reasonable increase.

In the system presented in the above named article it appears to me that thermal efficiency will be low because the temperature of the gases leaving the turbine will be high, and the expansion will not be as complete as with the steam turbine. Removal of the tar, which is a combustible, and production of ammonia, which requires the combining of nitrogen and hydrogen, will also tend to reduce the thermal efficiency. The inefficiency of the air compressors will be to some extent compensated for by using the cooling water in the steam boiler. This will also apply to the cooling water for the turbine bearings, and the other water-cooled parts. It is also probable that more steam will be generated than will be needed for the production of gas, since the heat content of the gas will be less than that of the steam. It is my opinion that, when all of the different conditions are thoroughly analyzed, it will be found that the gas engine of the reciprocating type is better adapted to transform the chemical energy of the gas into mechanical or electrical energy.

Reference may also be made to the mercury vapor boiler, but this would probably be too costly for electrochemical work.

A steam-power plant using turbines, proper temperatures, and the suitable apparatus to obtain maximum economy, when placed so that coal can be obtained at low cost, and supplied with an ample supply of cooling water, will, when operated with load factors characteristic of the electrochemical industries, supply power at a cost comparing with the best water-power rates.

G. H. F.

Tug River Elec. Co.
Williamson, W. Va.

Canadian Metal Production.—The Canadian Department of Mines estimates the production of metals from Canadian ores for 1917 as follows: Copper, 113,000,000 lb.; nickel, 84,800,000 lb.; lead, 56,700,000 lb.; zinc, 31,000,000 lb.; gold, 17,000,000 oz.; silver, 23,500,000 oz. About 1,186,000 short tons of pig iron were produced and 1,735,000 tons of steel ingots and castings. The production of gold, silver, copper and coal was less than in 1916. The others mentioned were greater.

A New Water-Power Program in Congress

RECENT important developments in Washington indicate that the administration proposes to accomplish something definite in the development of the water power of the country. For several years past there have been independent programs in the House and Senate covering the development of water power on the public domain and on navigable streams, but due to a lack of co-ordination of the several governmental departments involved, nothing of consequence has resulted. Senate and House apparently have taken irreconcilable positions in the past. Both have passed measures, but neither has been able to agree with the other.

A part of the trouble is due to the complexity of our administration of internal affairs. The public domain is under the control of the Secretary of the Interior, except for forest reserves, which are controlled by the Secretary of Agriculture. Navigable streams, on the other hand, are under the control of the Secretary of War. Hitherto the attempt has been made to pass separate measures pertaining to water power on navigable streams and on the public domain, but the present effort is directed toward a co-ordination of the interests of the three departments.

On Jan. 4 the President held a conference with members of various committees of the House of Representatives, at which the passage of water-power legislation was urged. The personnel of the conferees is significant of the plan to harmonize the several factors concerned. Present at the conference were Thetus W. Sims, chairman of the House Committee on Interstate and Foreign Commerce, who has recently succeeded Judge Adamson in that position; Scott Ferris of Oklahoma, chairman of the House Public Lands Committee; Asbury F. Lever of South Carolina, chairman of the House Agricultural Committee, and Edward W. Pou of North Carolina, chairman of the House Rules Committee, as well as Finis J. Garrett, the ranking member of the House Rules Committee.

The President committed to the care of Representative Pou a copy of a new water-power bill, which will be known as the Administration bill, which attempts to co-ordinate water-power legislation proposed for several years past in both Houses of Congress not only on the public domain but in navigable streams and national forests. The result of the White House conference, it is authoritatively stated in Washington, will be that the House Rules Committee will bring in a rule peremptorily requiring the House of Representatives to vote on and pass water-power legislation at an early date.

The bill was drawn by Gen. Black and Col. Keller, of the Army Engineer Corps, representing the War Department; Edward C. Finney, water-power expert for Secretary Lane, and former Representative Lathrop Brown of New York, now a special assistant to Secretary Lane, representing the Interior Department, and O. C. Merrill of the Forest Service, representing the Agricultural Department, who compiled, several years ago, a mammoth report on water-power companies, their banking affiliations, etc.

Provisions of the Administration Bill

Although most of the delay in water-power legislation has been due to Congress, some of it has been due to opposing views held by members of the Cabinet. These views have now been reconciled in the new Administration Bill, which provides for a Federal Power Commission, to be composed of three cabinet officers—Secretary of the Interior, Secretary of Agriculture and Secretary of War. It provides for an executive officer of the commission, who shall be appointed by the President for a term of five years. It provides for the payment of rentals of not less than 10 cents per horsepower per annum, a feature to which there has never been objection of consequence by any interest. The commission is empowered to grant licenses to develop water power on public lands and navigable streams for a term of fifty years. At the end of the license period the licensee upon application for a new license shall remain in undisturbed possession until the proposed commission shall have done one of three things: First, issue a new license under laws at that time applicable; second, give license to a new licensee who shall pay for the original fair value of the property; or, third, take the property over upon paying for its fair value. Fair value is defined to include actual cost of property taken plus severance damages for all property not taken over and damaged by reason of severance. Fair value does not include any allowance for enhancement of values on land or water rights granted by the United States, or good-will, going value or prospective revenues. The bill provides for alteration, amendment or repeal by Congress, which expressly reserves such rights, but in case of alteration, amendment or repeal such shall not extend to the licensees who have exercised rights, or spent money under the bill.

At the presidential conference it was agreed that a committee of five members each from the House Committees on Interstate and Foreign Commerce, Agriculture, and Public Lands, fifteen in all, should be created to compose differences as to the various bills which have been under consideration heretofore in the House and to bring together the radical and the more moderate views as to water-power development. The Committee of Fifteen, it is felt in Washington, will be materially aided in its labors by the fact that after mature deliberation, advice and conference, President Wilson himself has presented a bill upon which he believes all can agree.

The Senate's Shields Bill

What is to take place in regard to water-power legislation in the Senate is not yet known, as that body passed the Shields bill on Dec. 14. This measure deals only with the development of water power on navigable streams, and has no reference to water power on public lands. The latter is in the hands of a separate Senate committee. The principal objects of the Shields bill are thus summarized by Senator Jones of Washington:

1. For the improvement of the navigation of rivers without cost to the government in connection with dams constructed for hydroelectric purposes in navigable streams.
2. For grants by the Secretary of War of authority to private parties for the construction and maintenance of such dams when navigation facilities can be improved thereby, such authority to extend for fifty years and until the property necessary for such a development is taken over and just compensation paid for it either by the government or a duly authorized new grantee.
3. For diligent construction, completion and operation of such dams, subject to market conditions.

4. For the construction by the grantee of suitable locks, without cost to the government, when required by the Secretary of War.

5. For payment to the government by the grantee of the cost of any investigation necessary to the issuing of the grant and the cost of such supervision of construction as may be necessary; and also the payment by the grantee of reasonable charges for benefits resulting from headwater improvements installed by the government and payment to the government of a reasonable price for the use of any public land taken.

6. For the regulation of the rates and service of the grantee by state authority, or, if the business is interstate, by the Interstate Commerce Commission, thereby assuring to consumers efficient service and fair, just and reasonable rates.

7. For reserving to the state authority over the waters and water powers subject to the paramount power of Congress over navigation, and for reserving also all the taxing powers of the states in relation to the properties.

8. For uniform accounting and examination of the books of grantees by the Secretary of War.

9. For leasing under similar conditions the right to utilize surplus water generated at dams constructed by the government.

Senators in charge of water-power legislation in the upper house also are expecting to have White House conferences, and it seems certain that the Administration bill will be introduced in the Senate or that its provisions will come before a Senate Committee in some form, so that when the House passes the Administration bill there may be a conference between the House and the Senate. This will give opportunity to compose the differences between the Administration bill, the Shields bill already passed by the Senate, and the provisions of any measure relating to the public lands which may come from the lands committee of the Senate.

Award of Medal at Annual Meeting of Mining & Metallurgical Society of America

The annual meeting of the Mining & Metallurgical Society of America was held at the Engineers' Club, New York City, on Jan. 8, 1917. At the afternoon session the following officers were elected: President, W. R. Ingalls; vice-president, J. Parke Channing; secretary-treasurer, L. D. Hunton; members of council, F. W. Bradley, J. V. N. Dorr, J. R. Finlay, Pope Yeatman, R. C. Gemmell.

Honorary membership in the Society was conferred on Dr. James Douglass and Prof. James F. Kemp.

The gold medal of the Society was awarded to Pope Yeatman for distinguished service in the administration of mines.

At the evening session there was some discussion of the surtax on professional incomes as imposed by the War Revenue Act, and a motion was passed declaring it to be the sense of the meeting that the surtax is inequitable and unjust. This action was communicated to the Engineering Council for such action as it might deem wise.

Following the transaction of business the Society listened to informal talks on conditions in Russia by J. P. Hutchins and F. W. Draper. Both of these engineers were able to speak from personal knowledge of events as observed during residence in Russia. Mr. Draper told the story of his experience in bringing from Russia to the United States over 20,000 oz. of platinum for the use of our Government, a task which he had only recently completed.

New Home of Dayton Engineers' Club

The Engineers' Club of Dayton, Ohio, comprising about 300 engineers in all fields of activity, has completed a handsome new club house at Monument Avenue and Jefferson Street, facing the river, and convenient to the center of the city. It is in keeping with the progressive spirit of the city, and is three stories high, facing 150 ft. on Monument Avenue and 125 ft.

NEW HOME OF DAYTON ENGINEERS' CLUB

on Jefferson St. The first floor has a ladies' room, billiard and game room, large main dining room, and small private dining rooms. On the second floor is a large auditorium, a library, and lounging room. On the third floor are bedrooms.

The club will be dedicated on Saturday afternoon and evening, Feb. 2. Invitations are being sent out throughout the Miami Valley. Col. E. A. Deeds, chief of the Aircraft Production Board, is president of the club, and Mr. C. F. Kettering vice-president.

Program of New York Meeting of A. I. M. E.

The 116th meeting of the American Institute of Mining Engineers will be held in New York from Monday, Feb. 18, to Thursday, Feb. 21 inclusive. The committee on arrangements consists of J. E. Johnson, Jr., chairman; Bradley Stoughton, vice-chairman; Ralph W. Deacon, J. V. N. Dorr, L. W. Francis, Mrs. S. J. Jennings, A. R. Ledoux, F. T. Rubidge, E. M. Shipp, G. D. Van Arsdale and A. L. Walker. The summarized program follows:

Monday, Feb. 18:

9 a. m. to 5 p. m., registration at Institute headquarters.

10 a. m. and 2 p. m., technical sessions.

12.30 p. m., luncheon at Engineering Societies' Building.

8.30 p. m., war smoker.

Tuesday, Feb. 19:

10 a. m. and 2 p. m., annual business meeting and technical sessions.

12.30 p. m., luncheon at Engineering Societies' Building.

8.30 p. m., announcement later.

Wednesday, Feb. 20:

10 a. m. and 2 p. m., technical sessions.

12.30 p. m., luncheon in Engineering Societies' Building.

7 p. m., "Hoover" dinner at Hotel Biltmore.

Thursday, Feb. 21:

All-day excursion to Princeton to visit aviation field.

An attractive program is being prepared for the ladies.

Licenses Required to Handle Ammonia Products

A proclamation has been issued by the President requiring the licensing of the importation, manufacture, storage and distribution of the following necessaries: Ammonia, ammoniacal liquors, and ammonium sulphate from whatever source produced. The proclamation continues as follows:

All persons, firms, corporations, and associations (except those specifically exempted by said act of Congress) engaged in the business of importing, manufacturing, storing or distributing ammonia, ammoniacal liquors, or ammonium sulphate from whatever source produced, are hereby required to secure a license on or before Jan. 21, 1918, which will be issued under such rules and regulations governing the conduct of the business as may be prescribed.

The Secretary of Agriculture shall supervise, direct, and carry into effect the provisions of said act.

Applications for licenses must be made to the law department, license division, United States Food Administration, Washington, D. C., upon forms prepared for that purpose.

Employees' Responsibility on Secret Processes

An interesting and important decision was recently handed down by the Supreme Court of the United States in the case of Walter E. Masland vs. E. I. du Pont de Nemours & Co. The former was formerly in the employ of the du Pont company and the company sought to restrain him from using or disclosing secret processes in artificial leather manufacture which it was claimed he had learned while in their employ. He claimed that the process was not secret and that he did not expect to use information gained in confidence. He was prevented by the court, however, from revealing to experts or other witnesses the data claimed as secret by the du Pont Company. The Circuit Court of Appeals reversed this decision however, but it was upheld by the Supreme Court. Their statement follows:

"The case has been considered as presenting a conflict between a right of property and a right to make a full defense, and it is said that if the disclosure is forbidden to one who denies that there is a trade secret, the merits of his defense are adjudged against him before he has a chance to be heard or to prove his case. We approach the question somewhat differently. The word property as applied to trade-marks and trade secrets is an unanalyzed expression of certain secondary consequences of the primary fact that the law makes some rudimentary requirements of good faith. Whether the plaintiffs have any valuable secret or not, the defendant knows the facts, whatever they are, through a special confidence that he accepted. The property may be denied, but the confidence cannot be. Therefore, the starting point for the present matter is not property or due process of law, but that the defendant stood in confidential relations with the plaintiffs, or one of them. These have given place to hostility, and the first thing to be made sure of is that the defendant shall not fraudulently abuse the trust reposed in him. It is the usual incident of confidential relations. If there is any disadvantage in the fact that he knew the plaintiffs' secrets, he must take the burden with the good.

"The injunctions asked by the plaintiffs forbade only the disclosure of processes claimed by them, including the disclosure to experts or witnesses produced during the taking of proofs—but excepting the defendant's counsel. Some broader and ambiguous words that crept into the decree, seemingly by mistake, may be taken as stricken out and left on one side. This injunction would not prevent the defendant from directing questions that should bring out whatever public facts were nearest to the alleged secrets. Indeed, it is hard to see why it does not leave the plaintiff's rights somwhat illusory. No very clear ground as yet has been shown for going farther. But the judge who tries the case will know the secrets, and if in his opinion and discretion it should be advisable and necessary to take in others, nothing will prevent his doing so. It will be understood that if, in the opinion of the trial judge, it is or should become necessary to reveal the secrets to others, it will rest in the judge's discretion to determine whether, to whom, and under what precautions, the revelations should be made."

Fifth National Foreign Trade Convention

The National Foreign Trade Council has called the Fifth National Foreign Trade Convention to meet at the Gibson Hotel, Cincinnati, on Thursday, Friday and Saturday, Feb. 7, 8, 9. The part of foreign trade in winning the war will be the theme of the convention.

All Americans engaged in, or desirous of entering overseas commerce, and especially all chambers of commerce, boards of trade, and other commercial and industrial organizations, as well as firms and individuals, are invited to take part, individually or by appointment of delegates, in this convention.

Approximately one-half of the time of the convention will be given to the presentation of prepared papers and reports dealing with one or another of the numerous phases of this great convention theme. The remainder will be devoted to group sessions for the intensive discussion of concrete problems, under the leadership of specially qualified experts. The departments of government dealing with foreign trade matters, including the War Trade Board, and other war organizations, will lend their hearty co-operation.

The offices of the council are at No. 1 Hanover Square, New York.

Technical Association of Pulp and Paper Industry

The annual meeting of the association will be held at the Waldorf-Astoria in New York on Tuesday, Wednesday and Thursday, Feb. 5, 6 and 7. The executive committee will meet on Tuesday and a general meeting will be held on Wednesday morning. On Wednesday afternoon separate sectional meetings will be held on "Acid Sulphite Manufacture and Problems Relating to Engine Sizing." The annual dinner will be held Wednesday evening.

Société de Chimie Industrielle

The New York Section of the Société de Chimie Industrielle will meet for organization immediately following the meeting of the British Society of Chemical Industry at the Chemists' Club, 50 East Forty-first Street, at 8.15 p. m., on Friday evening, Jan. 18. All those interested are earnestly requested to be present.

By-products from Garbage.—The Chicago Chemical Bulletin says that New York City's garbage, by treatment in a $3,000,000 recovery plant of the latest type (so-called Cobwell process, chemical) on Staten Island, yields the following commercial products: Grease for 70,000,000 cakes of soap, 1500 tons of nitrogen, 2000 tons of phosphoric acid, 500 tons of potash. The increased recoveries amount to 25 per cent more than under the best previous reduction methods used for New York's garbage.

Italian Leucitic Lavas as a Source of Potash

BY HENRY S. WASHINGTON

WITH the present urgent need of potash to replace that which was previously sent out from Germany, other sources of supply of this substance assume great importance. In recent publications of the United States Geological Survey, Phalen[1] and Gale[2] describe the different sources in considerable detail, though confining themselves chiefly to those in the United States. While some of these sources appear to be promising, at least under present conditions, others, even at maximum possible utilization, can furnish but a small fraction of what is needed.

The igneous rocks of the earth's crust contain, on an average, about 3 per cent of potash (K_2O), some of them running as high as over 10 per cent. It is upon these, and especially those richest in potash, that the world will ultimately have to depend in great part for its supply.[3] At the present time, it would seem, no satisfactory practicable method has yet been devised for the extraction of potash from these rocks on a large commercial scale which could compete successfully with the German potash deposits in normal times. The solution of this important problem must be left to the future, and the subject will not be considered here.[4] It will, however, not be amiss to call the attention of those interested in potash to what may justly be considered as the greatest accumulation of very highly potash-rich igneous rocks known to exist on the earth's surface—the leucitic lavas of the Italian volcanoes.

Well known as they are to geologists, it is somewhat surprising that little or no mention is made of these rocks by writers dealing with sources of potash. Phalen, Gale, and Pogue, in the papers already cited, when enumerating the silicates possibly capable of yielding commercial amounts of potash, discuss feldspar, sericite, glauconite, and the lavas of the Leucite Hills in Wyoming, but make no mention of those of Italy, presumably because they were dealing more especially with possible domestic sources of supply. The Italian lavas are briefly alluded to by Schultz and Cross[5] in a paper devoted to the Wyoming rocks. Both De Launay[6] and Lindgren[7] dismiss leucitic rocks from consideration as a practicable source of supply because of the difficulty of extraction. Both of these authors, however, were writing before the present highly abnormal conditions obtained.

In their own country the Italian lavas have received some attention. Monaco[8] has published several short papers describing the results of experiments in treating the rock powders with dilute solutions, in simulation of the action of soil fluids, a small amount of potash being extracted. Moderni,[9] prior to the outbreak of the war, published a paper in which he briefly describes the different Italian volcanoes that furnish leucitic rocks, with descriptions of the more important lava flows, and their possible utilization as a source of potash.

Leucitic Rocks

It would not be appropriate here to go into detailed, technical descriptions of the Italian leucitic rocks,[10] but it may be well to devote a few words to them, as the use of some technical terms is necessary in describing the volcanoes and their rocks.

The minerals which are especially important for their potash content in the Italian rocks are two in number, both silicates of potash and alumina, but with different ratios of silica to the other two oxides.

Leucite

The most important, because it is the richer in potash and the more abundant in these lavas, is leucite. Although met with in volcanic lavas in various localities in different parts of the world, leucite is rather a rare mineral, except along the line of the Italian volcanoes, where it may be said to be characteristic of the lavas. It is white or light grayish, with a dull luster, and almost invariably in well formed crystals which, though bounded by crystal faces, are spherical in general form. Theoretically leucite ($KAlSi_2O_6$) contains 21.5 per cent of potash (K_2O), with 23.5 of alumina (Al_2O_3) and 55 of silica (SiO_2), but analyses show that the natural crystals actually contain about 19.5 of potash, the smaller percentage being due to the presence of small amounts of soda and other impurities. The fresh mineral contains no water. Leucite is readily decomposed by acids, the potash and alumina going into solution, and the silica being left in granular form. The Italian leucite crystals vary much in size, from that of a tennis ball or larger, through sizes of a walnut or a pea (these being much more common), down to microscopic dimensions, so that often to the naked eye the rock does not appear to contain leucite. In places, especially among some of the incoherent tuffs, there are masses made up almost wholly of loose leucite crystals, generally of medium sizes.

Orthoclase

The other mineral, orthoclase (potash feldspar) is much less abundant and of less importance than leucite in most of the Italian leucitic lavas. Elsewhere, throughout the world, it is much the more abundant and important of the two. It is typically white, with a

[1] W. C. Phalen, Potash Salts, 1915, U. S. Geol. Surv., Mineral Resources, 1915, II (12), pp. 95-133, 1916.
[2] H. S. Gale, Potash in 1916, U. S. Geol. Surv., Mineral Resources, 1916, II, pp. 73-171, 1917.
[3] Cf. J. E. Pogue, Fertilizers, U. S. Nat. Museum, Bull. 102, Part 2, p. 18, 1917.
[4] The extraction of potash from silicate rocks will be discussed in a paper that is to appear shortly.
[5] A. R. Schultz and W. Cross, Potash-bearing Rocks of the Leucite Hills, U. S. Geol. Surv., Bull. 512, 1912.
[6] L. De Launay, Gites Mineraux et Métallifères. Paris, 1913, II p. 100.
[7] W. Lindgren, Mineral Deposits, New York, 1913, p. 243
[8] E. Monaco, Sull' Impiego delle Roccie Leucitiche, Le Stazioni sperimentali agrarie italiane, XXXVI, p. 577, 1903; ditto, XXXVII, p. 1031, 1904; ditto, XXXIX, p. 340, 1906
[9] P. Moderni, Le Leucitiche dei Vulcani Italiani, L'Industria Chimica, Mineraria e Metallurgica, 1, 1914.
[10] For complete, petrographic descriptions and analyses of the various types see H. S. Washington, The Roman Comagmatic Region, Publication No. 57, Carnegie Institution of Washington, 1906. Descriptions will also be found in most of the papers cited later in connection with each volcano.

vitreous luster, and cleaves readily in two directions. When crystallized the crystals very frequently have a tabular form. Theoretically pure orthoclase ($KAlSi_3O_8$) contains 16.9 per cent of potash, with 18.4 of alumina and 64.7 of silica. Actually, however, all the "orthoclase" of the Italian volcanoes (as well as nearly all of it elsewhere), contains varying, and sometimes large, amounts of soda feldspar (albite), so that the actual amount of potash present varies from less than 7 to about 10 per cent. In a very few Italian leucitic rocks the amount of orthoclase exceeds that of the leucite, but in the great majority it is much less, and in a large number of leucitic lavas it is wholly absent.

The chief minerals associated with these in the Italian lavas are soda-lime feldspars (silicates of alumina, soda and lime, of variable composition), and augite (silicates of iron, lime, magnesia, and a little alumina). In some of the lavas either or both of these may be present in amounts equal to that of the leucite. Other minerals occur as rock constituents in these lavas, such as olivine, nephelite, sodalite, magnetite, and apatite, but usually only in very minor amounts, so that, in general, they would not affect the percentage or the practical extraction of potash.

The leucitic rocks of which these minerals are the constituents must be described very succinctly. They may be broadly divided into three main groups, called respectively leucite trachytes, leucite tephrites, and leucitites.

LEUCITE TRACHYTES

The leucite trachytes are light gray and generally quite compact. They are composed essentially of sodic orthoclase and leucite, the former in some cases more abundant than the latter, with very subordinate amounts of soda-lime feldspar, augite, and other minerals. In these rocks the leucite crystals frequently attain large dimensions, while, in general, the orthoclase exists for the most part in microscopic size. As a class they are the richest in potash, averaging about 9.68 per cent K_2O, and some of them showing percentages of 10.40, 10.47, 10.49 and 10.63.

LEUCITE TEPHRITES

The leucite tephrites are dark gray to nearly black, and are usually compact. They are composed essentially of leucite, augite and soda-lime feldspar, with very small amounts of other minerals. Few of them show leucites visible to the naked eye, and then the crystals are small. As a usual thing leucite and augite each make up about 30 per cent of the rock, with the feldspar in somewhat less amount. Their potash content varies from about 7.50 to over 8 per cent, and they are much higher in lime, iron and soda, and lower in silica, than the preceding type.

LEUCITITES

The leucitites are dense, black, basaltic rocks, which scarcely ever show visible crystals of any sort. They are composed essentially only of leucite and augite, which constitute about 80 per cent or more, with very small amounts of other minerals. Their potash content is about that of the leucite tephrites, though slightly lower as a rule, and otherwise in chemical composition they much resemble these, but mineralogically and chemically the two types tend to grade into each other.

The average potash content of the Italian leucitic lavas, as shown by 27 complete chemical analyses made by me,[11] embracing representatives of all the types, is 8.72 per cent; while the average for all the lavas of these volcanoes, leucitic and non-leucitic, based on 44 analyses, and taking into account the relative abundance of the various kinds,[12] is 8.31 per cent. No other region of igneous rocks of commensurate, or even far greater, size is known that is so high in potash.

These leucitic lavas form flows that vary greatly in dimensions; up to 20 or more kilometers long and several kilometers broad, where not covered by tuffs, and as thick as 10 or more meters. In a general way it may be said that their exposed portions are from 1 to 5 kilometers in length, by about one or less in breadth, and with an average thickness of from 4 to 5 meters. They frequently show prismatic or platy parting, which facilitates extraction. Many of the flows are extensively quarried for paving blocks, which are commonly used in this part of Italy.

In addition to the lavas which carry leucite there are others at some of the volcanoes that are free from leucite, but contain large amounts of orthoclase or other feldspars. These are trachytes, andesites and basalts. The potash content of the trachytes (orthoclase lavas) varies from about 7.50 to over 9 per cent. The few andesites and basalts contain little potash. There are also very extensive beds of more or less incoherent tuffs, derived from the loose ashes and scorias thrown out by the volcanoes. While some of these are not leucitic, many of the them are quite rich in this mineral and contain very considerable percentages of potash.

Methods of Cubature

The method adopted by me for calculating the volumes of the volcanic masses was as follows: As they all have an approximately circular plan, with sides that slope up (more or less regularly) to a circular summit, the form was assumed to be that of a frustum of a cone. The irregularities of the sides, due to erosion or the presence of small, flank eruptions, were disregarded as of negligible magnitude for the rough calculations involved, and they tend more or less to balance each other. No correction was made for the natural concavity of the sides of a volcanic cone, as the error involved is small and is compensated by the lava flows that extend beyond the assumed base.

At the topographically highly irregular Bolsena and Bracciano volcanoes, the base selected was the sedimentary platform on which the volcanic mass rests; while at the more regular Vico, Alban Hills, Rocca Monfina and Vesuvius volcanoes it was assumed to be the lower border of the main cone, where it merges into the nearly horizontal lava flows and sheets of tuff that extend around it. This base would be somewhat above the sedimentary platform, and so the estimated volumes for the lavas of these cones are rather too small. The assumed top circle of the frustum varies with the form of the volcano. At Bolsena, Vico and Bracciano it was assumed to be that of the rim surrounding the central lake or crater, an average height above the base being

[11] H. S. Washington, The Roman Comagmatic Region, p. 146.
[12] H. S. Washington, The Roman Comagmatic Region, p. 174.

calculated for this, and the volume occupied by the central cavity being subtracted. At the Alban Hills, Rocca Monfina and Vesusvius, where, of the original early crater wall there remains only a semicircular ridge, the top is the approximately circular floor of the crater of the first eruptive period, inside the semicircular ridge. The volume of this ridge, together with that of the latest small, terminal cone (except at Rocca Monfina) is added to that of the main cone.

The formula used was that for a frustum of a cone:

$$V = \tfrac{1}{3}\pi h(a^2 + ab + b^2),$$

where h is the height from base to top, and a and b the radii of the base and top circles.

V. Sabatini[13] adopted a different method for the cubature of the Alban Hills and Vico, though, as his object was the calculation of the total existing material ejected; his bases are more extensive than mine, especially at the former volcano. The areas included by the successive 50-meter contour lines were measured with a planimeter, and the volumes of a series of annular cylinders were calculated, whose bases were these areas and whose heights were about the mean altitudes.

The Volcanoes

The Italian volcanoes[14] that are characterized by leucitic lavas are seven in number, forming a row that extends from Orvieto at the northwest to Naples at the southeast (a distance of about 300 kilometers), parallel to and quite near the west coast of the Italian peninsula. Vesuvius alone is active, the others having been long extinct, and some of them have largely lost their original forms through erosion.

Bolsena Volcano

The most northerly and the largest is that known as the Bolsena Volcano[15], which lies just west of Orvieto and some 90 kilometers northwest of Rome. It is the earliest in geological age of the seven, and is considered by some to be the remains of one huge volcano, while others consider it to be a complex of four moderate sized cones. Into this question we need not go. The total area covered by its volcanic rocks is about 2289 square kilometers.[16]

In the center is an elliptical lake, Lake Bolsena, 305 m. above sea level, with an area of about 115 square kilometers and a maximum depth of 146 meters. Surrounding this is a broad girdle of hills, made up of lavas and tuffs, with numerous, radiating erosion valleys and lava flows, extending to the borders of the area. The slope, in general, is upward from the borders of the mass toward the hills encircling the lake (these having an average altitude of about 300 meters above its level). But the topography is distinctly irregular and largely determined in details by the erosion of the various cones that compose the group. The diameter of the almost circular igneous area is about 40 kilometers, and the average altitude of the sedimentary base, though somewhat variable, may be taken as about 230 meters above sea level.

Apart from a few flows of non-leucitic rocks (andesites and trachytes), which cannot make up 10 per cent of the lavas, the rocks are highly leucitic lavas and their tuffs. Incidentally, it may be mentioned that the lavas of the Bolsena Volcano are more varied than those of almost any of the other volcanoes along the line. From the specimens collected by myself, and from the descriptions by others, though a complete study has not yet been made, it would appear that, of the lavas, leucite tephrites are somewhat the most abundant, leucite trachytes almost as much so, and leucitites in less amount. It would also appear that leucite trachytes predominate in the northwestern sector of the area, leucite tephrites northeast and southwest of the lake, and leucitites to the southeast.

So far as I am aware, no attempt has been made to calculate the volume of the Bolsena Volcano or of its lava flows—a problem which, indeed, can only be solved in a very rough way, because of the irregular topography. The result will, at least, give the order of magnitude and a rough approximation of the volumes involved. From the data furnished by the excellent Italian topographic maps, some of which have been given above, we obtain a total volume for the present volcanic mass of 178.9 cubic kilometers. Deducting from this the volume occupied by the lake and its basin, 46.2 cubic kilometers, there remains a volume of about 133 cubic kilometers of igneous rocks (lavas and tuffs) now existing above the sedimentary platform of the volcano. It is difficult to estimate the relative amounts of lavas and tuffs, but from my observations in the field it would seem to be reasonable to consider that the lavas form one-tenth of the mass. Of these lavas we may very liberally allow one-tenth for those which are non-leucitic. We thus obtain a final result of about 12 cubic kilometers of leucitic lavas, an estimate that may be considered to be conservative. Assuming that the average specific gravity of the rocks is 2.8, and that the potash content is about 8 per cent, this being based on a number of good analyses and study of my specimens, we arrive at a final total of 2,688,000,000 metric tons of potash (K_2O) contained in the leucitic lavas of the Bolsena Volcano.

Vico Volcano

This volcano[17] lies a few kilometers to the southeast of the Bolsena Volcano, 65 kilometers northwest of Rome, the city of Viterbo being at its north foot. It is one of a pair of volcanoes, but as the other, Monte Cimino, has poured out no leucitic lavas, this will not be considered here.

The Vico Volcano forms a quite regular cone, much better preserved and simpler than Bolsena. The cone proper has a circular base, at an altitude (average) of about 330 meters above sea level, and with an area of about 350 square kilometers, though extensive, thin beds of tuff extend beyond this. In the center is a nearly circular crater pit, about 9 kilometers in diam-

[13] V. Sabatini, Vulcano Laziale, p. 134; Vulcani Cimini, p. 269.

[14] It may be pertinent to mention that my knowledge of these volcanoes and their lavas is the result of studies in the field and in the laboratory extending over many years.

[15] H. S. Washington, Italian Petrological Sketches, Jour. Geol., IV, pp. 541-566, 1896; P. Moderni, Studio Geologico dei Vulcani Vulsini, Bolletino Comitato Geologico, 1904, 234 pp., with topographic map 1:100,000. It is to be noted that references to only two or three of the most descriptive papers are given in the case of each volcano, as the literature is far too extensive for full citation here.

[16] In this paper all measurements are given in the metric system, as this is the official system of Italy and all the maps on which the calculations are based are in accordance with it. It will be useful to note the following approximate equivalents.

1 meter	=	39.37 in. or 3.28 ft.
1 kilometer	=	0.62 mile
1 square kilometer	=	0.39 square mile
1 cubic kilometer	=	0.24 cubic mile
1 metric ton	=	2,205 lb. = 1.1 short ton

[17] H. S. Washington, Italian Petrological Sketches, Jour. Geol., IV, p. 826, 1896; V. Sabatini, Vulcani Cimini, Mem. Carta Geol. Ital., XV, 1912. Geological map, 1:75,000.

eter and 275 meters deep. The ridge surrounding the crater is rather sharp and has an average height above the base of about 450 meters. On the crater floor is a small, solid cone, Monte Venere, which is 320 meters high, near the foot of which is a small, shallow lake.

The lavas of Vico are much more uniform than those of Bolsena. There is a small proportion, less than 10 per cent, of trachytic rocks which, though they contain orthoclase instead of leucite, carry about 9 per cent of potash. Of the other lavas the greater part are leucite trachytes (often with abundant and large leucite crystals), and less leucite tephrites, while leucitites seem to be absent. In potash content the lavas range from 10.47 to 7.47 per cent, with an average of about 9.25.

Because of the fair state of preservation of the originally quite regular cone, the calculation of the volume of this volcano is simpler and susceptible of more accuracy than that of Bolsena. It has already been carried out by Sabatini, whose results will be given presently. Using the data given above, we obtain a total volume for the cone above the sedimentary platform of 83.4 cubic kilometers, to which is to be added 0.6 for the mass of Monte Venere, making a total of 84. From this is to be subtracted the volume of the crater, about 3.5 cubic kilometers, leaving a final volume of volcanic rock of 80.5 cubic kilometers. Assuming, as before, that the lava-flows form about one-tenth of the mass, the average specific gravity as 2.8 and the average potash as 9 per cent, we get a total potash content of 1,668,600,000 metric tons.

Using a somewhat different method, Sabatini[18] obtains a total volume of igneous material above the sedimentary base of 96.3 for both Monte Vico and Monte Cimino. Of these combined masses, according to his figures, Monte Vico makes up 84 per cent, so that his estimate for the Vico Volcano alone would be 80.6 cubic kilometers, a figure in very good agreement with that obtained by me independently, 80.5, using a different method.

BRACCIANO VOLCANO

This volcanic area[19] lies south of the preceding one, and about 25 kilometers northwest of Rome. The igneous rocks cover an area of about 1300 square kilometers, and the topography in its general features resembles that of the Bolsena Volcano, but on a somewhat smaller scale. There is a central lake, Lake Bracciano (area 57.5 square kilometers), the circle of hills about it being highest, 440 meters above the lake, on the northwest, and lowest on the south. It would appear that the mass is a complex of small cones, possibly parasitic to a large central one; but erosion has so altered the original forms that decision is difficult. Thus, the topography of the area is very irregular, though in a general way the surface slopes upward toward the hills bordering the lake.

The lavas of this volcano are predominantly leucite tephrites and leucitites, with very few leucite trachytes in the northwestern sector, and a few occurrences of non-leucitic trachytic rocks. Few good analyses of the lavas of this volcano have been made, but these indicate that they have an average potash content of about 9 per cent. One of the leucite trachytes contains 10.49 per cent.

Because of the highly irregular topography any satisfactory or approximately exact calculation of the volume of the igneous mass, and especially of that of the leucitic lavas, is very difficult. I have attempted it in a rough way, using the data of the Italian topographic maps, with the following results, which must be regarded as only a very rough approximation. The total volume of the volcano is about 48 cubic kilometers, from which is to be subtracted the volume of the lake basin (11 cubic kilometers), leaving for the volume of the igneous rocks 37 cubic kilometers. Assuming that the leucitic lavas constitute 10 per cent of this, with a specific gravity of 2.8, and 9 per cent of potash, they would contain 932,400,000 metric tons of K_2O.

ALBAN HILLS

This volcano[20], also called the Latian Volcano, lies about 13 kilometers southeast of Rome. It forms an isolated conical mass, with the original volcano form fairly well preserved. From a very extensive, very gently sloping base of tuffs, with some long lava flows, the cone proper (having an area at its base of about 345 square kilometers), rises to a circular ridge, with elevations of from 550 to 940 meters above sea level. This incloses the old crater floor, about 10 kilometers in diameter and with an elevation that may be placed at about the 600-meter contour line, the sedimentary base being assumed to be at about 200 meters. In the center rises a small, terminal cone, with the remains of a crater. Several small crater lakes, due to side eruptions, are found on the flanks of the main cone.

The lavas of this volcano are remarkably uniform, leucitites being overwhelmingly predominant, with very rare leucite tephrites. There are no leucite trachytes, or trachytic or andesitic rocks. Tuffs are abundant, but they, especially those that make up the cone proper, are mostly leucitic. Good analyses of these lavas are not numerous, but they indicate that the average potash content is somewhat over 8 per cent.

The cubature of this volcano has been carried out by Sabatini, whose results will be given below. Using the data given above and others derived from study of the map, I obtained the volume for the main cone, above the 200-meter contour line (which is approximately that of the encircling railroads or the lower limit of the area of leucitic tuffs given on Sabatini's map), of 78.5 cubic kilometers. Adding to this the volumes of the small cone, 2 cubic kilometers, and that of the ridge, 2.5 cubic kilometers, we get a total volume of about 83 cubic kilometers. Assuming, as before, that the lavas constitute one-tenth of this, have an average specific gravity of 2.8, with an average potash content of 8 per cent, they would contain some 1,859,200,000 tons of K_2O.

Sabatini,[21] using the method outlined above, obtained results which, though differing somewhat from mine, are fairly concordant, considering the differences in method. His area at the altitude of 174 meters (the nearest taken by him to my base altitude of 200), is 327 square kilometers, my figure, on the assumption that the base is circular, being 345. The volume of the cone from this 174-meter base to the altitude of 608

[18] V. Sabatini, Vulcani Cimini, p. 262, 1912.
[19] H. S. Washington, Italian Petrological Sketches, III, Jour. Geol. V, p. 34, 1897; P. Moderni, Le Bocche Eruttive dei Vulcani Sabatini, Bolletino Comitato Geologico Italiano, p. 1, 1896. Topographic map, 1:100,000.

[20] V. Sabatini, Vulcani Laziale, Mem. Carta Geol. Ital., X, 1900. Geological map, 1:75,000.
[21] V. Sabatini, Vulcano Laziale, p. 134.

meters is 93 cubic kilometers, my result from the 200 to the 600-meter levels being 78.5.

HERNICAN VOLCANOES

In the valley of the Sacco River, about 65 kilometers southeast of Rome (the country of the ancient Hernici), are the remains of about eight small volcanic cones.[22] These are composed almost entirely of leucite tephrites and their tuffs, the lavas containing about 8 per cent of potash. They might contain in all something like 100,000,000 tons of potash; but the amount is so small and their distance from industrial centers is so great that they need not be considered in the present connection.

ROCCA MONFINA VOLCANO

This volcano[23] lies about 50 kilometers north of Naples, between the Garigliano and Volturno Rivers. Its igneous rocks cover an area of about 225 square kilometers. In general structure this volcanic mass much resembles Vico, the Alban Hills and Vesuvius, though it is not quite as well preserved. There is a large main cone, surmounted by a semcircular ridge, which reaches on the west a height of 926 meters above the sea, the original ridge being worn down to a series of low hills on the east. The original circular crater floor, something like 400 meters above the base,[24] has a diameter of about 6 kilometers. From the center of this rises a small cone, Monte Santa Croce, of non-leucitic andesite.

The lavas of this volcano are almost as varied in their characters as those of Bolsena. There are some flows of non-leucitic lavas (basalts, andesites, trachytes), but the leucitic lavas preponderate very greatly, and would seem to be rather more abundant relatively to the tuffs than in the other volcanoes. All three kinds are found, leucite tephrites being the most abundant, with leucitites and leucite trachytes probably in the order named. The last are especially noteworthy, as are some of the tuffs, for the abundance of very large leucite crystals. There are but few satisfactory analyses of the lavas of this volcano, but a conservative estimate would place the average potash content at at least 9 per cent. One leucite trachyte contains 10.64 per cent, the highest figure for potash obtained in the Italian lavas.

In the absence of adequate topographic data, the cubature of this volcano must be regarded as but roughly approximate. It is estimated that the cone, from the base to the crater floor, has a volume of about 40.5 cubic kilometers, to which is to be added the volume of the semicircular ridge, approximately 2.5, making a total of 43 cubic kilometers. Assuming that the lavas are at least one-tenth of this, and the non-leucitic flows[25] one-tenth of the lavas, there is left a volume of about 4 cubic kilometers of leucitic lava flows. With an average specific gravity of 2.8, and a potash content of 9 per cent, these would contain 1,008,000,000 tons of K_2O, a figure which, by comparison with the analogous volcanoes of Vico and the Alban Hills, I consider to be much below the true one.

VESUVIUS

This, the only active volcano of the series,[26] lying some 10 kilometers east of Naples, is so well known that it calls for little description. Leaving out of account the extensive beds of tuff that cover the surrounding Campagna, the area of the base[27] of the cone is about 80 square kilometers, the average altitude of the boundary being about 150 meters above the sea. The cone slopes quite regularly up to the Pedimentina, a circular plateau at an altitude of 600 to 800 meters. This is bounded on the north by the narrow semicircular ridge of Monte Somma, which rises to a maximum height of 1132 meters above sea level. Near the center of the Pedimentina is the modern cone, about 2 kilometers across at its base and 400 meters high. The present crater at the summit of this cone is about 1000 meters in diameter and 320 meters deep.

On the whole, the lavas of Vesuvius are very uniform and are all leucitic. With the exception of some of the flows of Somma and a few early beds of pumice, they may be referred to the leucite tephrites with scarcely an exception. Judging from observations on the inner walls of Somma and of the active crater, lava-flows and dikes are quite abundant as compared with the tuffs and ashes. The average potash content of the Vesuvius lavas is between 7.50 and 8.00 per cent.

Well known and much studied as is Vesuvius, it is rather remarkable that no attempt appears in its literature to calculate its volume. Using the data given above, supplemented by study of the topographic map, it is estimated that the main cone, from the base of 150 meters to the Pedimentina, has a volume of 20 cubic kilometers. To this must be added the volume of the Somma ridge above the Atrio level, 0.5, and that of the modern cone, 0.7 cubic kilometers, making in all a total of at least 21 cubic kilometers. Considering the relative abundance of the lava flows and dikes, and the fact that most of the ashes and scorias are high in potash, it would seem reasonable to assume that the lavas make up about one-seventh of the mass. On this basis, and with an average specific gravity of 2.8, and potash content of 7.5 per cent, we obtain 8,400,000,000 tons of leucitic lava, containing 630,000,000 tons of potash.

Immediately west of Naples is a volcanic district, the Phlegrean Fields, which covers about 150 square kilometers, and in which are found about twenty-six small cones. These are mostly of non-leucitic tuffs, with some lava flows, all of them non-leucitic orthoclase trachytes. They average about 8 per cent in potash content.

RECAPITULATION

For convenience the various data set forth in the preceding pages are here tabulated:

[22] W. Branco, I Vulcani degli Ernici. Neues Jahrbuch für Mineralogie, 1877, p. 561. Geological map, 1: 86,400; C. Viola, Osservazioni Geologiche fatte nella Valle del Sacco, Boll. Com. Geol. Ital., 1896, p. 4, map.

[23] L. Bucca, Il Monte di Rocca Monbina, Boll. Com. Geol. Ital., 1886, p. 245; P. Moderni, Note Geologiche sul Grunpo Vulcanico di Rocca Monfina, Boll. Com. Geol. Ital., 1887, p. 74. Geological map, 1:100,000. H. S. Washington, Italian Petrological Sketches, IV, Jour. Geol., V, p. 34, 1897.

[24] As my copies of the Italian topographic maps are not available at the time of writing, this altitude is not certain, but, from analogy with the other volcanoes, is believed to be a conservative estimate.

[25] The mass of Monte Santa Croce is disregarded in the calculations.

[26] J. Phillips, Vesuvius, Oxford, 1869, 355 pp.; J. L. Lobley, Mount Vesuvius, London, 1889, 400 pp. (both are popular descriptions); H. J. Johnston-Lavis, The Geology of Monte Somma and Vesuvius, Quart. Jour. Geol. Soc. Lond., XL, p. 35, 1884; A. Lacroix, L'Eruption du Vesuve (April, 1906), Paris, 1907, 169 pp.; Topographic Map, Scale 1: 75,000, Instituto Geografico Militare, 1908.

[27] The boundary of this is approximately the highway that encircles Vesuvius, passing through Pollena, Somma, Ottaiano, Avini, Bosco Tre Case, and the railroad just above Torre del Greco and Portici

SUMMARY OF DATA AS TO POTASH IN LEUCITIC LAVAS OF ITALIAN VOLCANOES

Volcano	Area of Base Km²	Alt. of Base* Met	Average Height Main Cone†	Total Volume‡ Volcano Km³	Leucitic Lavas Metric Tons	Per Cent K_2O	Amount of Potash Metric Tons
Bolsena	2289	230	350	133	33,600,000,000	8	2,688,000,000
Vico	350	330	450	80 5	18,540,000,000	9	1,668,600,000
Bracciano	1300	220	200	37	10,360,000,000	9	932,400,000
Alban Hills	345	200	400	83	23,240,000,000	8	1,859,200,000
Rocca Monfina	225	200	400	43	11,200,000,000	9	1,008,000,000
Vesuvius	80	150	550	21	8,400,000,000	7.5	630,000,000
Total	...	....	.....	.....	105,340,000,000	....	8,786,200,000

*Above sea-level. †Above base. ‡Corrected for crater, etc.

In considering these figures it must be borne in mind that in nearly, if not quite, all respects they are thought to be under, rather than over, estimates. This, on the following grounds. The dimensions and volumes of the calculated volcanic masses are those of the main cones, and, except in the cases of Bolsena and Bracciano, disregard portions of flows extending beyond the limits of the bases selected. The assigned altitude of the base above sea-level has been liberally high, and the average height of the cone above it is regarded as, in general, rather under than above the truth. The choice of figures for specific gravity and potash percentage have also been moderate. It is thought that the only factor that may be possibly too high is the assumption that the lavas constitute one-tenth of the volcanic mass. This, however, is based on rather extensive observations in the field, as well as on consideration of the fact that in the mass of the main cone, which alone has been considered in the preceding calculations, the relative amount of lava to tuffs and scoria is always very much greater than in the outlying or surficial portions of the volcano. This is well seen in the walls of Somma, the crater of Vesuvius, the walls of Val del Bove at Etna, in the crater of this volcano, and elsewhere. Even if somewhat high, it is to a certain extent compensated by the disregarding of the tuffs and scorias in the calculations, though many of these contain large percentages of potash. It would, therefore, be reasonable to suppose that the row of Italian volcanoes contains at least some 10,000,000,000 tons of potash (K_2O). It may be of interest to remark that the average annual consumption of potash in the United States for the ten years from 1905 to 1914 was almost exactly 200,000 short tons,[28] so that these volcanoes represent, "on paper," a 50,000 years' supply.

Practical Considerations

As was stated at the beginning of this paper, possible methods for the extraction of the potash from these rocks fall outside of the scope of this study and so will not be discussed here. It may be well, however, to point out very briefly some of the local features that may have a practical bearing.

All the volcanoes lie close to main, and in some cases also to subsidiary, railroad lines now in operation, and all, with the exception of Bolsena, near or not very far, from, large cities, either Rome or Naples.

As to power, although Italy is lacking in true coal, yet there is a very considerable amount of water power. Some of this has been utilized in late years in Lombardy and Piedmont, and there must be a noteworthy supply available in the streams that flow down the west slopes of the Appennines, though, not being a hydraulic engineer, I am not competent to discuss the subject. It may be mentioned that Moderni[29] calls attention to the fact that, at the Bolsena Volcano the Paglia River, which flows around its northern border, can furnish up to 260 hp., while the Marta, that drains the lake at the southeast, would yield up to 753 hp.

Although these volcanoes are surrounded by towns and villages, yet the main slopes of most of them, except the Alban Hills, are for the most part neither well populated nor highly cultivated. This is especially true of the Bolsena, Vico, Bracciano and Rocca Monfina volcanoes. At present there are very numerous, one might well say almost innumerable, lava-flows, varying in dimensions from 2 to 10 or more meters thick and up to 20 or 30 kilometers long, that are readily workable. Indeed, according to Moderni (page 10 of the paper just cited), leucite and leucitic lavas were extracted from the Alban Hills "for industrial purposes" (i. e., not for paving, but presumably for fertilizer uses) to the total amount of 22,300 tons in the years from 1903 to 1909, inclusive. Many quarries have been opened at several of the volcanoes, notably Bolsena, Alban Hills and Vesuvius, for the extraction of paving stones and their refuse, as pointed out by Moderni, would serve as a source of immediate supply of considerable magnitude.

In this connection it may be of interest to note that, according to Moderni, German industrial societies had in recent years, before the war, been active in researches in the Italian leucitic lavas for the manufacture of "chemical products."

Comparison with Other Regions

Although occurrences of leucitic lavas are scattered rather sporadically over the earth's surface, they are actually very rare rocks, and no other region is as yet known that is so extensive or so rich in them as that of the Italian volcanoes.

The occurrence that first calls for consideration is the very frequently mentioned district of the Leucite Hills, in Wyoming.[30]

A few other localities where leucitic rocks occur in the United States are known, as in Montana, the Yellowstone Park, Arkansas and New Jersey, but these can be of no commercial importance. The lavas of the Leucite Hills are highly potassic, averaging 10 per cent, and in this respect they slightly surpass those of the Italian volcanoes, whose average is nearly 9 per cent. As regards area, volume and amount of potash present, however, they are relatively insignificant. As calculated by Schultz and Cross (p. 35), the total tonnage of the leucitic rocks, including at some of the stocks the rock masses down to a depth of 3000 feet,[31] is 1,973,496,177 short tons, or about 1,794,100,000 metric tons of rock, containing 179,410,000 metric tons of potash. This is about one-fiftieth of the estimate of the potash contained in the Italian lavas, which we have reason to believe to be below the truth. In the one case it is a matter of acres, of area and feet of height, in the other

[28] See H. S. Gale, U. S. Geol. Surv., Min. Res., 1916, Pt. II, p. 76, 1917.

[29] P. Moderni, L'Industria Chimica, etc., I, p. 23, 1914.

[30] For a description of this as a source of potash see Schultz and Cross, Potash-bearing Rocks of the Leucite Hills, U. S. Geol. Surv., Bulletin 512, 1912. A full bibliography is given.

[31] Disregarding these, the lavas above the surface amount to about 1,627,819,000 short tons.

square kilometers of area and tens of meters of height of lava-flows.

Another silicate source of supply of potash in the United States (though not an igneous rock), is that of the beds of glauconite or greensand marl, of Upper Cretaceous and Eocene age, that extend in a narrow belt from near Sandy Hook, N. J., to beyond, Richmond, Va.[2] Clauconite is essentially a hydrous silicate of iron and potassium. The portions of the deposits that lie in New Jersey are the richest in potash, and a content of 6 per cent in the air-dry material would be a fair estimate for them. In New Jersey the belt is 160 kilometers long, with an average width of 16 kilometers. Assuming an average thickness of 6 meters (about 20 feet) for the glauconite beds, and the above percentage of potash, these New Jersey deposits would contain about 2,034,000,000 metric tons of potash, or about one-quarter or one-fifth of that contained in the Italian volcanoes. It would therefore appear that these glauconite beds of the Eastern States rank next to the Italian volcanoes in total amount of potash. The ease of extraction of the raw material and their proximity to facilities for treatment and transportation would seem to promise them to be of great value.

[2]See Lewis and Kümmel, Geol. Sur. of N. J., Bull. 14, p. 135, 1915; G. H. Ashley, U. S. Geol. Sur., Bull. 660-B, p. 27, 1917.

Among other localities where leucitic lavas occur in considerable amount may be mentioned the islands of Java, Celebes and Baween in the East Indies, New South Wales, the Eifel and Baden in Germany, Bohemia, Kamerun and East Africa and the Antarctic. But none of these, with the possible exception of the East Indies lavas, would seem to be sufficiently abundant or with a high enough average potash content to give promise of a commercial source of supply.

SUMMARY

Attention is called, as a future possible source of potash, to the leucitic lavas of seven volcanoes along the west coast of Italy, from Bolsena to Vesuvius. The rock types are characterized and the several volcanoes described very succinctly. The volumes of the volcanoes, the tonnage of the lavas, the percentage of potash and the total (minimum) amount of potash at each, are calculated. It is shown that the leucitic lavas of these volcanoes, with an average potash content of about 9 per cent, contain at least 8,786,200,000 metric tons of K_2O, making them the greatest accumulation of highly potash-rich silicate rocks known. Methods of extraction of the potash are not discussed.

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The Effect of Addition Agents in Flotation—II

BY M. H. THORNBERRY AND H. T. MANN

As in the preceding discussion[1] of the effect of addition agents in flotation, the results obtained by the addition of various hydroxides are shown graphically in Charts 4, 5 and 6. The numerals on the charts are the numbers of the various experiments, three being made without any additions and four with each of the different agents. Those without addition agents are numbered 1, 2, 3 and 0, the last showing the average results of the first three. The numbers of experiments with addition agents are given in the following paragraphs, four to each experiment, and indicate results obtained respectively with 5, 15, 25 and 50 cc. of each agent.

To save repetition in the discussion of the results we shall refer in this article to Cleveland Cliffs Iron Company's flotation oil No. 1 as "oil No. 1," and to General Naval Stores flotation oil No. 17 as "oil No. 17."

The reader should also bear in mind that when statements are made that a certain reagent raised or lowered the grade of concentrate or extraction those results are compared with the results obtained when oil was used without any reagent.

HYDROXIDES

$(NH_4)OH$. Nos. 4 to 7

Ammonium hydroxides, when used with both oil No. 17 and cresylic acid, produced very similar results. The relative extraction was lowered about 7 per cent, while the grade of concentrate produced was only about 3 per cent low. With oil No. 1 both the extraction and grade of concentrate were lowered about 12 per cent.

NaOH. Nos. 8 to 11

When sodium hydroxide was used the results were so nearly like those of ammonium hydroxide that further discussion is unnecessary.

KOH. Nos. 12 to 15

Potassium hydroxide, when used with oils No. 1 and No. 17, lowered the extraction about 4 per cent, while the grade of concentrate produced was lowered about 6 per cent. Observations and results indicate that there is a possible relation between the flocculating effect of this salt and its effect on flotation results. However, it will take many more determinations to demonstrate the correctness or fallacy of this apparent relation. When this salt was used with cresylic acid the results checked more closely. The average extractions were lowered about 5 per cent, while the average grade of the concentrates was raised 2 per cent.

$Ba(OH)_2$. Nos. 16 to 19

With oil No. 1 barium hydroxide lowered the extraction about 15 per cent, and also lowered the grade of concentrate about 10 per cent. With oil No. 17 the extraction was lowered 7 per cent, while the grade of concentrate was lowered 4 per cent. With cresylic acid the extraction and grade of concentrate were lowered 9 per cent.

$Ca(OH)_2$. Nos. 20 to 23

Calcium hydroxide, when used with oil No. 1, gave extractions which varied from 2 per cent high to 5 per

[1]This Journal, Dec. 15, 1917, p. 709.

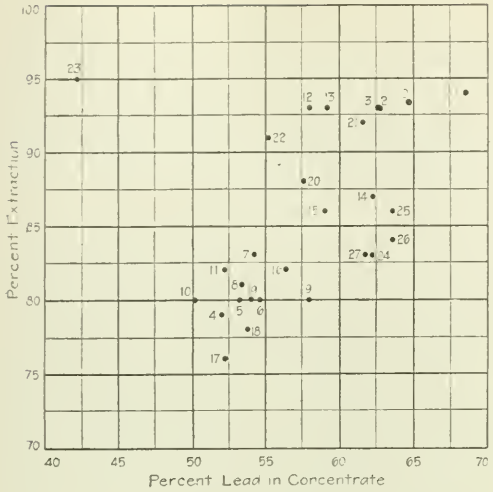

CHART 4—EFFECT OF HYDROXIDES ON FLOTATION OF GALENA WITH OIL NO. 1

cent low, while the lead tenor of the concentrate varied from 2 per cent low to 22 per cent low. With oil No. 17 the extraction varied from 4 per cent low to 10 per cent low, and the grade of concentrate varied from 2 per cent to 22 per cent low. With cresylic acid the extraction varied from 3 per cent high to about 8 per cent low, and the grade of concentrate varied from 2 per cent high to 6 per cent low.

Calcium hydroxide is practically the only hydroxide which exerted a pronounced effect on the character of the froth formed. With oil No. 1, 5 cc. of this salt gave a very wet froth composed of very small bubbles, which formed slowly and broke down very quickly. With 15 cc. the froth was wet, and composed of small bubbles which broke down slowly. With 25 cc. the froth was dry, and composed of large bubbles which formed quickly. With 50 cc. the froth was very dry, and composed of extremely large bubbles. This froth formed quickly and seemed to carry large quantities of gangue, and broke with difficulty. The froths with oil No. 17 were similar to those formed when oil No. 1 was used. With cresylic acid, 5 cc. of calcium hydroxide gave a wet froth composed of small bubbles which broke very quickly. The froth with 15 cc. was dry. When 25 cc. was used no froth was obtained when the usual quantity of oil—0.5 lb. per ton—was added. To complete the experiment another portion of oil equivalent to 0.250 lb. per ton was added. This extra addition of oil produced a froth composed of large bubbles which broke very quickly. With 50 cc. of this salt it was necessary to double the amount of oil before the tests could be completed. The froth formed when 1 lb. per ton of oil was added was extremely dry and composed of very large bubbles.

The relation between the flocculating effect of this salt and its effect on flotation deserves more work than we can devote to it at the present time.

The character of all froths formed was compared to the froths formed by the oil when no addition agent was present.

$Mg(OH)_2$. Nos. 24 to 27

Magnesium hydroxide, when used with any one of the three oils, lowered the extraction about 10 per cent, and had very little effect on the grades of concentrates produced. This salt modified the froths formed to such a little extent that no further discussion is necessary.

Summary of Effect of Hydroxides

The limited number of hydroxides tested, when considered as a group, produce results which are very similar to the results obtained when sulphates are present. The relative extraction is practically the same, but the grade of concentrates produced is slightly lower than when sulphates are present.

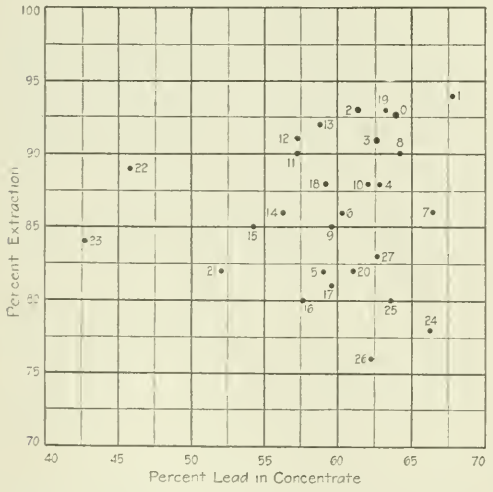

CHART 5—EFFECT OF HYDROXIDES ON FLOTATION OF GALENA WITH OIL NO. 17

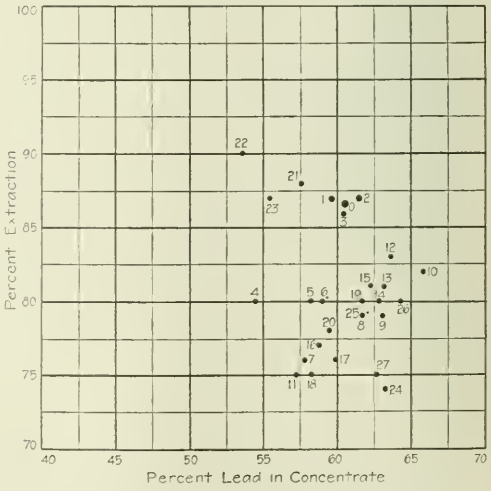

CHART 6—EFFECT OF HYDROXIDES ON FLOTATION OF GALENA WITH CRESYLIC ACID

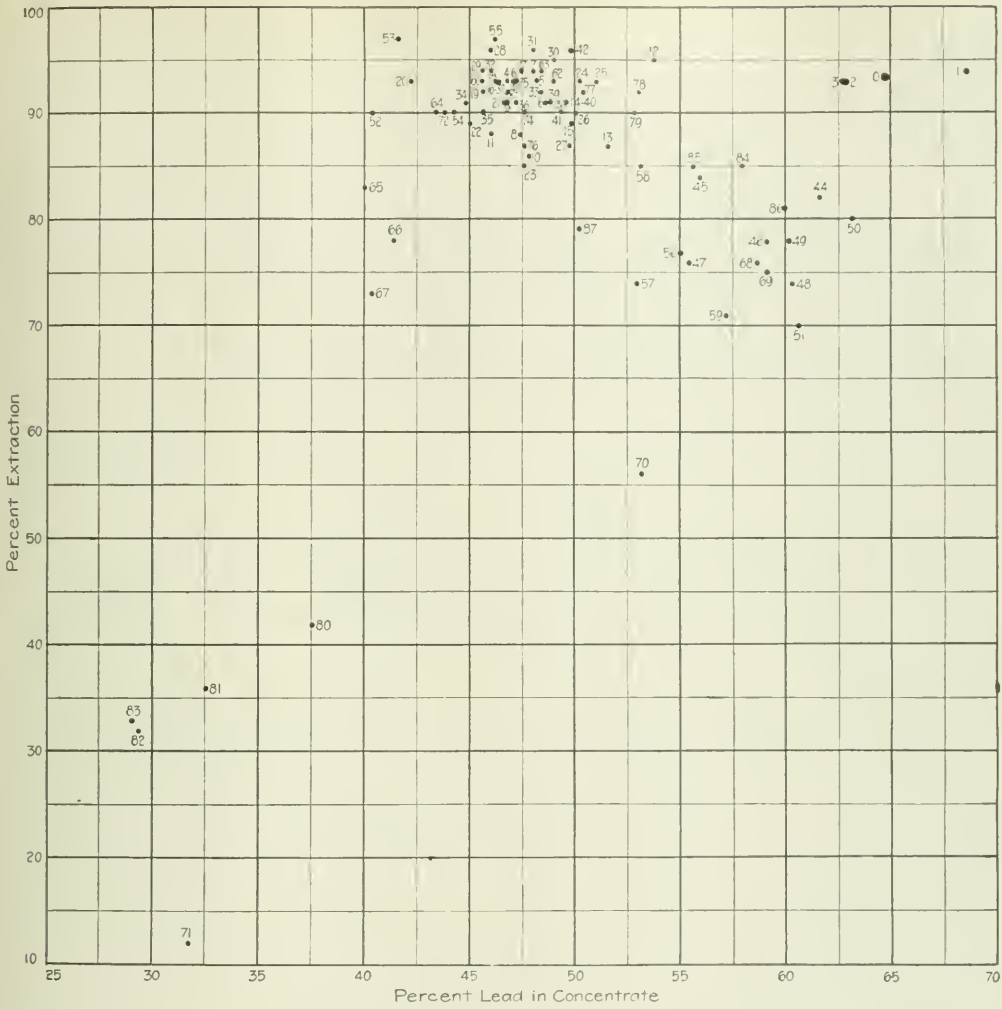

CHART 7—EFFECT OF NITRATES ON FLOTATION OF GALENA WITH OIL NO. 1

Nitrates

The results of these experiments are set forth in Charts 7, 8 and 9. Attention is here directed to the first three paragraphs of this article for an explanation of the significance of the numbers and their interpretation.

Nitric acid and many of the commoner nitrates when used in flotation tend to produce such an abundance of froth that it was found impractical to add the total amount of oil—0.5 lb. per ton—at the beginning of the test. When the total amount of oil was added at one time the entire amount of froth produced was evolved so quickly that an excessive overflow carrying large quantities of gangue was obtained, thereby necessitating the discarding of the test. To overcome this difficulty, the method of handling the nitrates was modified in the following manner: The desired quantity of the reagent having been added to the charge, oil was added at intervals in quantities equivalent to 0.125 lb. per ton. After each addition of oil the violent frothing was allowed to subside before another portion of oil was added. This procedure was continued until the total amount of oil—0.5 lb. per ton—had been added and the test was then completed, as described in the method for sulphates.

This tendency of quickly producing a very copious froth was so pronounced with nitric acid that it was found impossible to complete an experiment in which acid had been used. After twelve of fifteen trials with the acid, its use was abandoned.

The character and quantity of froth obtained when the nitrates were used varied widely. Small quantities of one reagent produced a froth composed of large bubbles, while larger quantities of the same reagent produced a froth of small bubbles. This condition was reversed with some of the other reagents. Repeated

tests, however, with the same addition agent under uniform operating conditions maintained in this work, always gave a froth having the same characteristics as mentioned above.

Many of the tests were completed in from 25 to 30 minutes, but were continued the full 40 minutes in order to keep operating conditions as uniform as possible.

Alkali Metal Nitrates

$NaNO_3$. Nos. 4 to 7.

Sodium nitrate had practically no effect on the extraction when used with oils No. 1 and No. 17, but when used with cresylic acid the extraction is noticeably lowered. The effect on the grade of concentrate produced was just the opposite. The grade of concentrate with oil No. 1 was lowered about 16 per cent; with oil No. 17 it was lowered about 8 per cent, while with cresylic acid the concentrate was of about the same grade as that produced when no reagent was present.

With oils No. 1 and No. 17 this salt gave a slow forming froth, which was composed of small, wet bubbles, which broke up slowly. With cresylic acid, sodium nitrate gave a dry, ephemeral froth, and the maximum extraction was obtained in 25 minutes.

KNO_3. Nos. 8 to 11.

Potassium nitrate, when used with oil No. 1 and cresylic acid, lowered the extraction more than the corresponding sodium salt. With oil No. 17 it had practically no effect on the extraction. The lead tenor of the concentrate varied with the oil used, being slightly higher with cresylic acid and about 14 per cent lower with oils No. 1 and No. 17.

With oils No. 1 and No. 17 the addition of 5 cc. of potassium nitrate solution produced a froth consisting of large, wet bubbles. When larger quantities were used the froth consisted of small, wet bubbles. With cresylic acid the froth formed slowly and consisted of large, dry bubbles, which broke quickly.

CHART 8—EFFECT OF NITRATES ON FLOTATION OF GALENA WITH OIL NO. 17

$(NH_4)NO_3$.
Nos. 12 to 15.

Ammonium nitrate lowered the extraction slightly when used with oils No. 1 and No. 17, and considerably when used with cresylic acid. It had practically no effect on the grade of concentrate produced when used with oil No. 17, and cresylic acid, but with oil No. 1 it lowered the grade of concentrate about 12 per cent.

This reagent, when used with oils No. 1 and No. 17, gave a very wet froth, composed of small bubbles which broke quickly. With cresylic acid the froth was not so wet, and the concentration was completed in 25 to 30 minutes.

$LiNO_3$.
Nos. 16 to 19

Lithium nitrate had little or no effect on the extraction. The lead content of the concentrate produced was about 16 per cent lower with oil No. 1,

12 per cent lower with oil No. 17, and 3 per cent higher with cresylic acid.

The froth formed when this salt was used varied with each oil. Oil No. 1 gave a wet froth, composed of medium-sized bubbles; oil No. 17 gave a froth similar to oil No. 1, except that the bubbles were much smaller. Cresylic acid gave a dry, ephemeral froth, composed of medium-sized bubbles, and the concentration was completed in about 25 minutes.

The alkali metal nitrates tested gave very similar results, the general tendency being to lower slightly the extraction. The effect on the grade of concentrate produced seemed to depend more on the oil used than on any particular nitrate of this class, or on the quantity of nitrate used.

When used with oils No. 1 and No. 17, which produce a high-grade concentrate without any reagent, the alkali metal nitrates lowered the grade of concentrate very noticeably, but when used with cresylic acid, which has a tendency toward making a low-grade product, these nitrates have practically no effect on the concentrate produced.

Alkaline Earth Nitrates

$Ba(NO_3)_2$. Nos. 20 to 23

Barium nitrate lowered the extraction about 4 per cent, regardless of the oil used. The effect of the grade of concentrate produced varied with the oil. Oil No. 1 lowered the lead tenor of the concentrate 18 per cent; oil No. 17 lowered the grade of the concentrate about 10 per cent; while with cresylic acid the concentrate was of practically the same grade as the one produced when no reagent was used.

The froths formed varied widely with this salt. With small quantities of barium nitrate, oil No. 1 gave a wet froth composed of medium-sized bubbles, which broke slowly, while larger quantities of this reagent gave a dry froth composed of large bubbles. With oil No. 17 the froth was very wet and had a long life. Cresylic acid produced a wet ephemeral froth, consisting of large bubbles, and the concentration was completed in 30 min.

$Ca(NO_3)_2.4H_2O$. Nos. 24 to 27

Calcium nitrate, when used with oils No. 1 and No. 17, had practically no effect on the extraction; but when used with cresylic acid the extraction was lowered about 7 per cent. The effect of this salt, when used with cresylic acid, on the grade of concentrate produced is practically nil, but when used with oils No. 1 and No. 17 the concentrate is lowered about 12 per cent.

The froths formed when using this reagent with oils No. 1 and No. 17 was composed of small, wet bubbles, which broke readily. With cresylic acid the froth varied from small, wet bubbles when small quantities of the reagent were used, to a dry, stiff froth with the larger quantities.

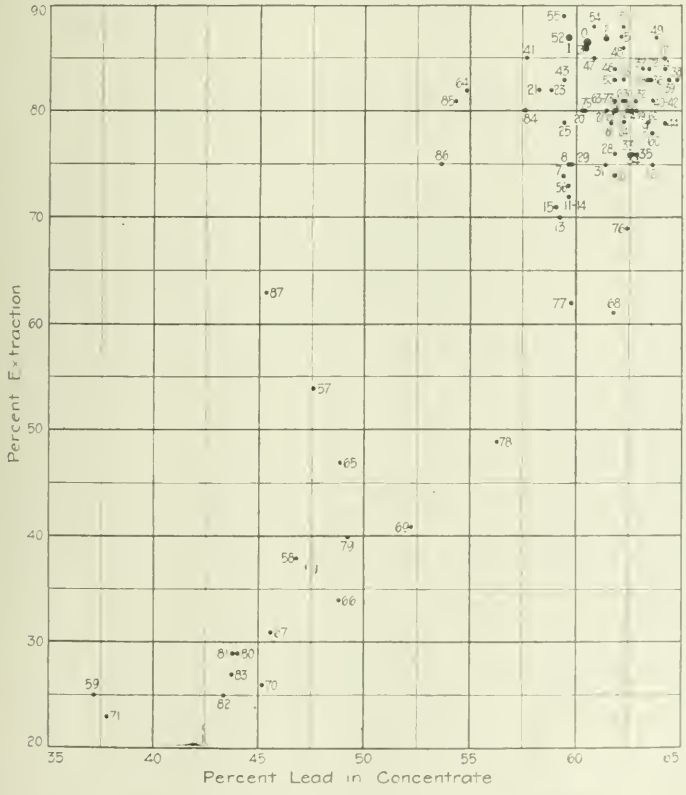

CHART 9—EFFECT OF NITRATES ON FLOTATION OF GALENA WITH CRESYLIC ACID

$Sr(NO_3)_2.4H_2O$. Nos. 28 to 31

The effect of strontium nitrate on both the extractions and grade of concentrates produced was very similar to those of calcium nitrate, regardless of the oils used. The froths which formed were likewise very similar to those of the corresponding calcium salt, with the exception that they contained more water.

$Mg(NO_3)_2.6H_2O$. Nos. 32 to 35

Magnesium nitrate is very similar in all its effects to the corresponding calcium salt.

When the alkaline earth nitrates are considered as a group, the results obtained correspond so closely with those obtained with the alkali metal nitrates that further discussion is unnecessary.

Metallic Nitrates

$Mn(NO_3)_2.6H_2O$. Nos. 36 to 39

Manganese nitrate lowered the extraction about 3 per cent, regardless of the oil used. The grade of concentrate was lowered about 16 per cent with oil No. 1, and about 4 per cent with oil No. 17, but with cresylic acid the concentrate was raised about 3 per cent.

The froth formed varied with the oil used. Oil No. 1 gave a wet froth, consisting of small bubbles; oil No. 17 gave a wet, ephemeral froth made up of medium-sized bubbles, and cresylic acid gave a dry, ephemeral froth composed of large bubbles.

$Ni(NO_3)_2.6H_2O$. Nos. 40 to 43

Nickel nitrate had practically no effect on the extraction when used with any one of the three oils. The grade of concentrate varied with the oil. When oil No. 1 was used the concentrate was lowered about 16 per cent. With oil No. 17 the concentrate was lowered about 14 per cent. The concentrate formed when cresylic acid was used was of about the same grade as that obtained when no reagent was present.

Oils No. 1 and No. 17, when used with 5 cc. of this salt, produced an ephemeral froth composed of very small bubbles. When larger quantities of the reagent were added, these oils produced a froth composed of very large bubbles, which had an exceptionally long life. Cresylic acid gave a dry, ephemeral froth composed of large bubbles.

$CO(NO_3)_2.6H_2O$. Nos. 44 to 47

With cobalt nitrate and oil No. 1 the extraction was lowered about 13 per cent. The effect of this salt is so nearly like the effect of nickel nitrate in all other respects that further discussion is unnecessary.

$Fe(NO_3)_2.6H_2O$. Nos. 48 to 51

The extractions obtained when ferrous nitrate was used varied more with the oil than with the quantity of the reagent added. With this salt and oil No. 1 the extraction was lowered about 17 per cent; when oil No. 17 was used the extraction was lowered only 4 per cent, while with cresylic acid the extraction is practically the same as when no reagent was present. The effect on the grade of concentrate produced was very slight. With oils No. 1 and No. 17 the concentrate was lowered about 3 per cent; with cresylic acid it was raised about 2 per cent.

The froths formed were very similar to those formed when nickel nitrate was used.

$Cu(NO_3)_2.6H_2O$. Nos. 52 to 55

Copper nitrate had practically no effect on the extraction when used with any one of the three oils. The effect on the grade of concentrate produced varied with the oil used. Oil No. 1 produced a concentrate which contained 22 per cent less lead than that obtained without a reagent. Oil No. 17 gave a 13 per cent lower grade concentrate, while cresylic acid gave a concentrate having practically the same composition as that obtained when no reagent was present.

The froth formed when copper nitrate was used with oil No. 1 consisted of very small, wet bubbles. Oil No. 17, when used with this salt, produced a froth composed of wet medium-sized bubbles, while cresylic acid produced a froth of very large, dry bubbles.

$AgNO_3$. Nos. 56 to 59

The results obtained when silver nitrate was used varied greatly. With oils No. 1 and No. 17, some of the extractions were lower than others, but this variation did not occur uniformly as the amount of silver nitrate solution was increased. With oil No. 1 the extractions varied from 10 per cent to 25 per cent low, while with oil No. 17 they varied from 8 per cent to 19 per cent low. The lead tenor of the concentrates with oil No. 1 was lowered about 10 per cent, while with oil No. 17 the grade of concentrate varied from 16 per cent to 20 per cent low.

When cresylic acid was used, both the extraction and grade of concentrate were lowered in accordance with the amount of silver nitrate present. When 5 cc. of the salt was present the extraction was lowered 14 per cent, while the lead tenor of the concentrate was lowered only 1 per cent. But when 50 cc. of the reagent was added the extraction was lowered 62 per cent, and the lead tenor of the concentrate 23 per cent. These results, when plotted, show a fair curve in which the extraction and grade of concentrate fall as the amount of silver nitrate is increased.

The character of the froths formed when silver nitrate was used varied widely. With oil No. 1 small amounts of this salt produced an extremely wet froth, but when the maximum amount of the salt was added the froth was exceedingly dry and very stiff. With oil No. 17 the froths were not as extreme as were those with the preceding oil. Cresylic acid produced dry, ephemeral froths composed of large bubbles which seemed to have very little carrying power.

$Pb(NO_3)_2$. Nos. 60 to 63

Lead nitrate, when used with oils No. 1 and No. 17, had no effect on the extraction, but when used with cresylic acid the extraction was lowered about 7 per cent. The concentrate produced follows the usual order, being about 17 per cent low with oils No. 1 and No. 17, and 2 per cent or 3 per cent high with cresylic acid.

The froths formed when this salt was used likewise follow the usual order; small, wet bubbles with oil No. 1 to large, dry bubbles with cresylic acid.

$Hg(NO_3)_2.H_2O$. Nos. 64 to 67

Generally speaking, mercuric nitrate had a detrimental effect both on the extraction and the grade of concentrate produced, regardless of the oil used. When used with oil No. 1, the extraction was lowered about 10 per cent, and the grade of concentrate about 22 per cent. When used with oil No. 17, the extraction was lowered about 18 per cent, and the grade of concentrate 20 per cent. When used with cresylic acid the effect on both the extraction and grade of concenrate is almost identical with the effect produced by silver nitrate.

The froths produced by mercuric nitrate were all wet, and varied only in the amount of water they contained.

$UO_2(NO_3)_2.6H_2O$. Nos. 68 to 71

Uranyl nitrate is another reagent which has a very detrimental effect on both the extraction and grade of concentrate produced. Its effect is very similar with all three oils, in that as the amount of uranyl nitrate solution was increased the extraction and the grade of concentrate were lowered.

There also seemed to be a relation between the character of froth formed and the extraction, in that the more water the froth contained the poorer the extraction. The froths formed very slowly, were very light, broke down quickly, and seemed to have no carrying power.

$Al(NO_3)_2.9H_2O$. Nos. 72 to 75

The effect of aluminium nitrate is practically the

same as with manganese nitrate, hence no further discussion is necessary.

$Bi(NO_3)_2.5H_2O$. Nos. 76 to 79

Bismuth nitrate, when used with oil No. 1, lowered the extraction about 5 per cent and the grade of concentrate about 15 per cent. When used with oil No. 17 and cresylic acid, both the extractions and the grade of concentrates were lowered as the amount of the salt was increased.

All the froths formed consisted of small, wet bubbles.

$Cd(NO_3)_2.4H_2O$. Nos. 80 to 83

Cadmium nitrate, like cadmium sulphate, had a very pronounced effect on the extraction and grade of concentrate, in that both were lowered enormously. When cadmium sulphate was used there seemed to be a marked relation between the amount of the salt present and the results obtained, but when cadmium nitrate was used this relation was not brought out so forcibly.

The froths formed with oil No. 1 and this nitrate were very wet, while with cresylic acid they were dry.

$Zn(NO_3)_2.6H_2O$. Nos. 84 to 87

Zinc nitrate lowered the average extraction about 12 per cent, and the grade of concentrate averaged about 8 per cent to 9 per cent low.

The froths formed varied from small, wet bubbles to large, dry bubbles, depending on the quantity of reagent added and the oil used.

Summary of Effect of Nitrates

The nitrates used, when considered as a whole, gave widely divergent results, which seemed to depend more on the oil than on any other factor.

When oil No. 1 was used the average extraction, with a few exceptions, was practically the same as when the oil was used without any reagent, but the average grade of concentrate produced was lowered about 17 per cent.

When oil No. 17 was used, the average extraction was lowered slightly, while the grade of concentrate was lowered from 8 per cent to 10 per cent.

With cresylic acid, the average extraction was lowered about 7 per cent, but the grade of concentrate produced was raised 2 per cent or 3 per cent.

The nitrates had a very striking effect on the character of the froth formed. When used with oil No. 1, the froth was usually composed of small, wet bubbles. In a few cases the bubbles were so small that the froth resembled a thick scum.

When oil No. 17 was used, the bubbles were larger and the froth was not so wet as that produced with oil No. 1.

When cresylic acid was used, the froth was usually dry, and composed of large bubbles, which seemed to have very little carrying power.

Experiment Station and Dept. of Metallurgy, School of Mines and Metallurgy, Rolla, Mo.

Work of the British Nitrogen Products Committee

Plans Under Way for Cyanamide, Ammonia, Oxidation, and Experimental Synthetic Ammonia Plants

ENGLAND has attacked the nitrogen problem much the same as the United States. A Nitrogen Products Committee was formed in June, 1916. following the formation of the Munitions Inventions Department. The Ministry of Munitions has recently issued a memorandum on the nitrogen problem and the work of the Nitrogen Products Committee, which we herewith reproduce from the Journal of the Society of Chemical Industry.

The Nitrogen Problem

The manufacture of the vast quantities of explosives that have been called for by the present conditions of warfare has led to an unprecedented demand for various nitrogen compounds. The world's consumption of nitrogenous fertilizers appears practically to double every ten years, and in 1913 had attained the large figure of 2,500,000 tons of Chile nitrate and about 1,400,000 tons of ammonium sulphate.

With the outbreak of the war the demand for explosives became of paramount importance and the requirements of agriculture for the time being took a secondary position. The prospect of world shortage of food, however, has served to bring the agricultural aspect of the problem again into the forefront. The researches of Sir William Crookes and of Lord Rayleigh upon the fixation of atmospheric nitrogen by means of the electric arc pointed the way to a method of utilizing the unlimited supply of nitrogen in the air.

The establishment on a very large scale during the past 20 years of processes for nitrogen fixation is one of the most striking electrochemical developments of modern times. Special reference may be made to the arc process, as used in Norway, the Haber or synthetic ammonia process developed in Germany, and to the cynamide process for the manufacture of nitrolim from calcium carbide, as carried on in Norway, Sweden, France, Italy, Germany and the United States.

In spite of the fact that the incentive to the commercial establishment of nitrogen fixation may be said to have originated in this country, no steps were taken in the United Kingdom to obtain nitrogen compounds other than cyanides synthetically. The ammonia recovered at gas works and coke ovens has constituted practically the only form of combined nitrogen produced in this country. During the war the command of the seas has hitherto enabled Great Britain to rely entirely upon importation for the whole of our supplies of nitrate of soda, the most important raw material of our explosives industry. The Central Powers, on the contrary, having been cut off from external supplies, were compelled to fall back upon their internal resources, with the result that nitrogen fixation processes, some of which were established commercially before the war, have been developed upon an enormous scale.

Soon after the formation of the Munitions Inventions Department in August, 1915, proposals for the fixation of nitrogen began to be received from inventors. These schemes were referred to the Chemical Inventions Com-

mittee of the Advisory Panel, but as they were isolated applications of the general problem and were of limited scope they did not immediately lead to any definite line of policy being taken upon the question. The importance of the problem was recognized, however, and the attention of the Minister was directed to it from time to time in the monthly departmental reports.

The inauguration of the submarine campaign in February, 1916, and the grave menace to overseas supplies of nitrates emphasized the importance of taking action on the matter. At this opportune moment a memorandum on the nitrogen problem was submitted to the Department by the Faraday Society. Several conferences were held to discuss the steps that should be taken, and, as a result, the Nitrogen Products Committee was constituted in the following June. Members of the Advisory Panel, representatives of other Departments of the Ministry of Munitions and of the Government, and delegates of the leading scientific societies were invited to serve. The terms of reference were:

(1) To consider the relative advantages for this country and for the empire of the various methods for the fixation of atmospheric nitrogen from the point of view both of war and peace purposes; to ascertain their relative costs, and to advise on proposals relevant thereto which may be submitted to the department.

(2) To examine into the supply of the raw materials required, *e.g.*, pure nitrogen and hydrogen, and into the utilization of the by-products obtained.

(3) Since some of the processes employed depend for their success on the provision of large supplies of cheap power to ascertain where and how this can best be obtained.

(4) To consider what steps can with advantage be taken to conserve and increase the national resources in nitrogen-bearing compounds and to limit their wastage.

(5) To carry out the experimental work necessary to arrive at definite conclusions as to the practicability and efficiency of such processes as may appear to the committee to be of value.

(6) As a result of the foregoing steps to advise as to starting operations on an industrial scale.

An important advance was made when the then Minister of Munitions, the Right Hon. E. S. Montagu, M. P., met the members of the committee on October 10, 1916. He assured them that the Government appreciated the importance of the nitrogen problem, and that he would do everything in his power to see that the recommendations ultimately made received the fullest consideration. At this meeting Sir William Crookes was able to be present. At the same meeting the organization of the committee was completed, and the following sub-committees were set up: Processes, Economics, Experiments, Power and General Purposes.

At a later date another sub-committee was found necessary to deal with the question of coal distillation processes and the production and utilization of power gas. The Gas Firing Sub-Committee was accordingly constituted. In all the committee and its sub-committees have held upwards of eighty meetings.

The necessity for research was evident from the outset, and the department at once took steps for the organization of a suitable research staff and the acquisition of a laboratory. Fortunately, the co-operation of the authorities of University College was secured, and a part of the new Ramsay Laboratory, at that time scarcely completed, was placed at the disposal of the department.

Nitrogen Fixation Research

The item placed first on the research programme was a complete investigation into the production of synthetic ammonia by the Haber process. The decision was influenced by the claims made for the process and by the commanding position it occupies in Germany, where the economic conditions as regards coal supplies and the comparative absence of water power are similar to those in Great Britain. Moreover, the almost complete lack of precise information concerning the commercial details of this process made it apparent that the research would present many unknown factors, and was therefore likely to occupy a considerable time.

Towards the end of the year the committee came to the conclusion that the ammonia oxidation process was well adapted as an emergency measure for securing quickly a considerable output of nitric acid or nitrates. Although already working with more or less success upon the Continent the process had not at that time been operated in this country. A systematic investigation of the most recent developments of the process was therefore undertaken.

Many important problems have arisen in connection with the two main researches indicated above. Reference may be made to such questions as the most efficient and commercially practicable catalysts for the synthesis of ammonia and for ammonia oxidation, and the commercial preparation in bulk and at a sufficiently low cost of hydrogen of the high degree of purity required for the synthesis of ammonia.

On account of the formidable technical difficulties presented by the different problems it was obvious that a research staff of considerable experience in all the recent developments of physical chemistry was needed for carrying quickly to a successful issue the work of the research program. In the selection of the personnel, therefore, endeavor was made to obtain men possessed of special qualifications. The department has been fortunate in securing a number of such men, with the result that the progress made has been more rapid than might have been expected under the present difficult circumstances. It may be mentioned that the chemist responsible for the research on the synthesis of ammonia had the advantage of having previously worked for some time on the problem at Professor Haber's laboratory at Karlsruhe.

In December, 1916, when the research work was in its early stages, a demonstration and lecture took place at the Research Laboratory and was attended by representatives of the Explosives Supply Department and of the War Office, and by delegates and members of other Government departments and of scientific societies. The Minister of Munitions was unable to be present, but early in 1917 he asked for practical recommendations to be submitted to him at any early date.

In view of the magnitude and complexity of the problem the committee was unable immediately to present a complete report. Certain definite conclusions had been arrived at, however, and these, together with recommendations thereon, were embodied in a unanimous

interim report which was submitted to the Minister of Munitions in February, 1917. The substance of the recommendations is given below:

Interim Report of the Committee

(a) *By-product Ammonia.*—The importance of increasing the output of by-product ammonia for munitions and for agriculture was pointed out. Steps were indicated whereby an increase could be obtained from existing gas works and coke oven plants. It was also recommended that action should be taken to avoid the loss of ammonia known to be occurring in certain districts.

(b) *Ammonia Oxidation Process.*—The erection at the earliest possible moment of plant capable of producing in the aggregate at least 10,000 tons of nitric acid per annum from gas works or coke oven ammonia was recommended

(c) *Cyanamide Process.*—The erection of a factory having an annual output of the order of 50,000 tons of cyanamide was recommended, the cyanamide to be utilized as such for agriculture or for the production of ammonia.

(d) *Synthetic Ammonia Process.*—The erection of a full-sized trial unit plant for synthetic ammonia process was recommended.

The Minister of Munitions invited members of the committee to meet him, and the recommendations of the interim report were discussed in detail. At the conclusion of this meeting the Minister appointed a small Executive Committee to supervise the action involved in giving effect to his decisions, and to report to him from time to time upon the progress made.

The Minister's Decisions and the Action Taken Thereon

The Minister's decisions were as follows:

(a) *By-product Ammonia.*—The committee was requested to deal with the problem of conserving ammonia and of augmenting the output on the lines of the recommendations.

(b) *Ammonia Oxidation Proccss.*—The Ministry of Munitions would undertake the installation of one Government plant on the lines suggested, or if the committee so advised the Ministry would agree to the erection of plants by suitable private firms. The information resulting from the research work was to be placed freely at the disposal of *bona fide* manufacturers, but was not to become the exclusive property of any firm or group of firms.

(c) *Cyanamide Process.*—The committee was requested to investigate the relative merits of a Government scheme and of other schemes that had been put forward involving private enterprise and to submit a report embodying definite proposals.

(d) *Synthetic Ammonia Process.*—The erection of the full sized trial unit was authorized.

In carrying out these decisions the Executive Committee dealt first with the problem of conserving and increasing the output of by-product ammonia. The co-operation of the Controller of Coal Mines, of the gas companies and of the domestic and industrial users of coke was enlisted, and the matter was then placed under the direction of the Explosives Department in March, 1917, in view of its existing organization for dealing with the supply of ammonia.

The next step taken was to summon a conference of manufacturers likely to be interested in the ammonia oxidation process, as a good deal of information had been collected regarding it and the research work had already reached a semi-commercial stage. Conferences took place at the Munitions Inventions Department in March, 1917, and were attended by representatives of a number of the more important interests. Several manufacturers at once agreed to take up the further study of the process with a view to its commercial development, and have since actively co-operated with the department. Some of them have already erected experimental plant on a considerable scale.

Encouraging progress continued to be made with the research, and arrangements and plans were made for the erection in London of a trial plant consisting of a single commercial unit designed to give an output of one ton of strong nitric acid per day. At this stage the work of establishing the process on a commercial scale for the manufacture of nitric acid and ammonium nitrate was handed over to the Explosives Department at their request in August, 1917. The work of investigation, however, has been continued at the Research Laboratory, as several important aspects of the process still remain to be explored.

With regard to the manufacture of cyanamide the Executive Committee came to the conclusion that the schemes involving private enterprise did not adequately fulfill the ends in view and recommended the erection of a factory by the Government. The committee proceeded to collect further information on cyanamide processes in actual operation and representatives proceeded overseas for this purpose. Complete details of a scheme involving a large scale factory with electric power station are now in course of preparation for submission to the Minister of Munitions.

Meanwhile a considerable amount of work had been carried out in connection with the synthesis of ammonia, including a detailed investigation of the whole of the conditions governing the process and of the efficiency and life of numerous catalysts. These studies led to the devising of a method of working whereby the output of ammonia per unit of catalyst space has been increased to a figure, which, as far as is known, exceeds anything hitherto attained. The design and erection of a semi-technical unit apparatus embodying a number of novel features, with the necessary pumps, circulators, gas holders, etc., was then undertaken. It is expected that the operation of the unit, which is now at work, will enable the remaining problems as to the chemical engineering details involved in the design of the full sized trial unit authorized by the Minister to be definitely settled.

Research upon the preparation of pure hydrogen in bulk has been carried on conjointly with the above investigations and arrangements have already been made for the trial on a semi-commmercial scale of a process that has given very promising results in the laboratory.

Nitrogen in Sulphuric Acid Manufacture

An important practical outcome of the conferences with manufacturers has been the introduction of ammonia oxidation plant to take the place of the nitre pots used in the manufacture of sulphuric acid by the lead chamber process. In pre-war times the annual con-

sumption of Chile nitrate for this purpose amounted to 18,000 tons. With the present increased output of sulphuric acid the consumption is greater, so that the possible saving of overseas freight is appreciable.

One of the small converters designed in and made for the Department Research Laboratory has been installed at the sulphuric acid works of Messrs. Brunner, Mond & Co. and has been working satisfactorily for some months. The firm is now arranging to adapt similar converters to the whole of their lead chambers. The United Alkali Co., the South Metropolitan Gas Co. and others are making arrangements to adopt the process and are utilizing two types of converter to the laboratory designs. Drawings have also been placed at the disposal of the Explosives Department for the benefit of other controlled establishments.

The apparatus is compact; the expense involved in its installation, apart from ammonia purification plant, is comparatively small, and its operation is simple. Arrangements have therefore been made for the rapid manufacture of the converters likely to be required, since it is believed that these designs may become standard types for the purpose in question. An explanatory pamphlet, compiled by the research staff and embodying detailed information concerning the construction and operation of the converters, will be available shortly for the use of firms who have already taken up the process or are desirous of doing so.

Further Research

Up to the present date the research has practically been confined to the two processes mentioned above and to problems arising therefrom. The investigations of the committee have shown, however, that many important and promising fields still remain to be explored.

Under present circumstances all activities have been concentrated upon processes which have a possible value as war measures and no attempt has been made to extend the programme of research beyond such limits. In view, however, of the national importance of the nitrogen problem, both now and in the future, it is hoped that definite arrangements will be made to preserve the continuity of the research after the war.

The Importance of Cheap Electric Power

It was recalled from the outset that the generation of electric power at a cost decidedly lower than has hitherto been attained in this country was a vital factor if an attempt was to be made to establish certain of the nitrogen fixation industries in Great Britain on a sound economic basis from the point of view of post-war competition. A thorough inquiry has therefore been made as to the possibility of cheapening the production of electric power from coal, not only by its generation in bulk with the most modern plant, but also by the use of methods involving carbonization and gasification, with recovery of the ammonia, fuel oils and other by-products hitherto wasted when raw coal has been directly used. The sub-committees concerned have had the advantage of obtaining the personal views of a number of experts who attended to give evidence on different aspects of the problem. This inquiry has been distinctly fruitful, and much detailed information has been collected.

Schemes for the utilization of various undeveloped water powers in the British Islands for nitrogen fixation have also been submitted and have been carefully examined. At least one of these schemes for hydro-electric development on a considerable scale presents *prima facie* prospects of becoming a valuable national asset. The Power Sub-Committee recommended that a survey should be made of the drainage area in question with a view to confirming the details of the scheme as submitted. The survey has recently been completed and is expected to result in the formulation of a definite development scheme for the utilization of this water power. It is estimated that the engineering work involved will take about two years to complete, and the scheme is therefore to be regarded as a post-war measure.

Costs of Operating Nitrogen Fixation Processes

Since many of the nitrogen fixation processes have not only a value for munitions but also a post-war importance, endeavors have been made to investigate the probable requirements of this country for nitrogen requirements of this country for nitrogen products. A detailed examination has been made of the production, consumption, imports and exports of such products, and special consideration has been given to the question as to the relative order of the costs involved in operating the synthetic and non-synthetic processes.

Most of the information relating to synthetic processes has had to be obtained from foreign sources, and the committee has been able to secure many figures of an authoritative character. The information thus collected has been subjected to critical examination in the light of manufacturing experience in allied industries and conclusions have been arrived at as to the costs likely to be incurred under British conditions.

The magnitude of this part of the inquiry may be measured when it is stated that the committee is in possession of comprehensive data concerning the cost of manufacture of:

(a) Nitric acid and nitrates by the older methods, and by the arc and ammonia oxidation processes.

(b) Calcium carbide and cyanamide.

(c) Ammonia and ammonium sulphate by the Haber and cyanamide processes.

(d) Hydrogen and nitrogen.

As well as concerning the costs involved in operating the Chili nitrate and the by-product ammonia industries.

Co-operation with Other Government Departments

Realizing that many of the branches of the committee's activities related to problems which were also occupying the attention of other Government departments, an attempt has been made to secure as far as possible co-operation and interchange of information. Thus on the question of the carbonization of coal, an exchange of views has taken place with the Fuel Research Board. On the question of the production of hydrogen on a large scale at the lowest possible cost a problem of great importance in connection with aeronautics, collaboration in experimental work with the Admiralty has been arranged. It will be noted that the constitution of the committee has provided for liaison with the Explosives Department, the Board of Agriculture, the Board of Trade and a number of scientific societies.

In accordance with the terms of reference the final report of the Nitrogen Products Committee will include

a review of the nitrogen problem as it affects the British Empire. This branch of the work has not yet been fully dealt with, but representations have been made to the Dominions, to dependencies (through the Colonial Office), to Egypt and to India informing the governments concerned of the activities of the committee and offering to place at their disposal all the information in the possession of the department.

As a result of the negotiations thus instituted the department is already in direct touch with official representatives of the Governments of Australia, Canada, New Zealand, South Africa, Africa, Egypt and Mysore, and also with important developments in other parts of India.

Nitrogen Fixation in Allied Countries

An interesting event was the visit to this country in February, 1917, of a delegation from the recently constituted Commission de l'Azote acting under the French Ministry of Munitions. It was soon evident that the delegation was most immediately interested in the various processes already established in this country for the manufacture of ammonium nitrate, and a visit of inspection to many of the controlled establishments was accordingly arranged through the Explosives Department.

Several conferences with the delegates were held at the M.I.D. during their stay in this country, and an interchange of ideas and information took place upon the most recent developments in nitrogen fixation in France and Switzerland. The entente thus established has been maintained by the periodical exchange of information and documents between the French Ministry of Inventions and the Munitions Inventions Department.

The Allied Governments of Italy and Russia have also nominated representatives to act in liaison with the department upon the nitrogen problem. The developments already accomplished in the countries in question have enabled these liaison officers to afford immediate and valuable assistance.

The action taken by the United States Government on the nitrogen question is also worthy of notice. Under the National Defence Act of 1916 a sum of £4,000,000 was set aside for the establishment in the United States of nitrogen fixation on a large scale. Committees of the Academy of Sciences and afterwards of the Ordnance Department were set up. Their advisers visited England, and the more important nitrogen-fixation installations on the Continent outside Germany. Upon the recommendation of their experts the U. S. A. War Department has decided to erect forthwith works for the manufacture of synthetic ammonia by a modified Haber process.[1]

Final Report of the Nitrogen Products Committee

The various sub-committees set up by the Nitrogen Products Committee have already completed or are now engaged upon their final reports. There will then remain the report of the main committee, which will of necessity be a somewhat detailed document owing to the scope of the inquiry that has been undertaken. Endeavors are being made to expedite the last stages of the work so that the final report may be available at the earliest possible date.

[1]Editor's Note: The War Department is also building a large cyanamide plant at Muscle Shoals. See our issue of Jan. 1, 1918, p. 1.

Current News and Notes

New Jersey Industries on War Basis.—New Jersey is the first state in the United States to undertake the organization of its manufacturing industries on a war basis, with the object of assisting the Government, and this step was taken Dec. 19 at the War Convention of the Manufacturers' Council of the New Jersey State Chamber of Commerce, held at the Robert Treat Hotel, Newark. The iron and steel industry was represented by L. S. Ayre, International Motor Co., Plainfield, N. J., and Arthur E. Barlow, Barlow Foundry Co., Newark.

Composition of Canadium.—Canadium is a composition alloy composed of 70 parts tungsten and 30 parts chromium, annealed. Trade name Canadium, sold by The Franklin Chemical Co., Ltd., London, England.

Chemists' Club for France.—An organization has been effected in France to be known as the Cercle de la Chimie, and will maintain headquarters at 54 rue de Turbigo, Paris. The *Revue des Produits Chimiques* will be the official organ of the Cercle de la Chimie. The club building will contain a reading room, a writing room, a lounge room and all the conveniences and comforts of a modern club. Provision is made for the holding of scientific meetings, and extensive literature will be available. Chemists and chemical engineers who go to France will welcome the opportunity to visit this club.

Colorado Scientific Society.—At the thirty-fifth annual meeting of the Colorado Scientific Society the following officers were elected to serve during 1918: President, Dr. Richard B. Moore; first vice-president, Mr. Lewis B. Skinner; second vice-president, Mr. Marmaduke B. Holt; treasurer, Mr. John W. Richards; secretary, Mr. Harry J. Wolf; executive committee: term expires Jan. 1, 1921, Mr. J. Claire Evans and Mr. M. S. MacCarthy.

Manganese Ore at Butte, Mont.—A reconnaissance of the Butte district was made recently by J. T. Pardee of the U. S. Geological Survey, who reports that the development of manganese ores at Butte has heretofore been wholly incidental to the production of silver, zinc, and lead, in the ores of which manganese minerals are among the chief components of the gangue. Except a few small lots used for fluxing at the smelters, no manganese ore was mined for manganese prior to 1917. As ores containing less than 25 per cent silica are rare in the district, the development of the lodes for manganese has lagged behind that in localities which produce ore of better grade. Systematic exploration of several of the larger manganiferous lodes has just begun, and search for pockets of marketable ore is being made in a small way by several lessees. The manganese ore is mostly oxidized and siliceous, and its content of manganese ranges from 10 to 37 per cent, but there are small quantities of high-grade ore, both oxide and carbonate. The main problems to be solved before Butte can become a factor in the manganese market under present conditions are (1) successful milling of the ores to produce a low-silica concentrate, and (2) briquetting the concentrate or otherwise making it acceptable to buyers. Milling tests have already been begun, but the results have not been entirely satisfactory, owing chiefly to losses in the tailings by sliming.

The Sulphuric Acid Situation in the United States

By LEWIS B. SKINNER*

PRECEDING the declaration of war, sulphuric acid in the United States was made exclusively either from "burner gases," produced in roasting zinc ores (blende) or pyrites, or from blast-furnace gases from the smelting of Tennessee copper ores. The pyrites-burning plants were situated more particularly along the Atlantic Coast, in the Southern fertilizer manufacturing areas, and on the Pacific Coast. Blende-roasting plants were situated in those Middle-Western districts where cheap coal and natural gas are available. In general, pyrites was obtained from three places: Spain, Canada and Virginia. After the war began, the Spanish supply was materially reduced and the Virginia supply has been curtailed as a result of a cave-in and flooding of the Arminius mine, Virginia's principal producer. Consequently a number of manufacturers have found it necessary to burn brimstone instead of pyrites. Fortunately for the United States we have two internal supplies of brimstone which were capable of immediate expansion to several times their former production.

For a while after the war was started the Southern fertilizer plant, with its adjunct of acid chambers, was curtailed in its production of complete fertilizer, and the acid plant was turned over to intense production for sale to powder makers. A number of small chamber plants, which had been built in connection with fertilizer factories, had been shut down before the war because it was commercially cheaper to purchase acid from some of the large producers, such as the Tennessee Copper Company, than to make this commodity on a relatively small scale. When the war demand came on these plants were put in as good shape as was practicable and started up, because, with soaring acid prices, it was quite profitable to operate plants that were almost ready for dismantling.

Production from Zinc-Acid Plants

The zinc-acid plants also were stimulated with equal intensity in both of their outputs, with the result that every possible arrangement for increased production was resorted to, even though recoveries were not good. Even Hegeler kilns, which are used almost exclusively in the United States for roasting ores in zinc-acid plants and which are known to demand a high amount of oxygen to finish the roast, were arranged to burn brimstone along with ore so as to increase acid production. The normal operation of these kilns for acid making results in the production of a weak gas, so that the chambers in such plants have to take care of an oxygen content far higher than that necessary for the actual chamber reactions. A suggestion to a number of such operators that melted brimstone be fed into the dust flues on top of the roaster, thus utilizing the otherwise objectionable excess of oxygen and securing greatly increased production for the same sized chamber layout, was followed. This procedure increased the chamber capacity about 20 per cent, other things being equal, and the practice soon spread to all zinc-acid plants. The high prices of zinc and acid prevailing shortly after the beginning of the war stimulated the addition of chambers, retorts and roasters in almost all of the zinc-acid smelters making sulphuric acid as a by-product. With the increased demand from the explosives manufacturers, steel makers, oil refiners and others, the demand for sulphuric acid has seemed to be unlimited and, throughout the war so far, its production has not caught up to the demand.

The zinc smelting plants that are situated in the Kansas-Oklahoma gas belt do not utilize the sulphur gas produced from roasting, because it is commercially practicable to roast by burning natural gas in direct contact with the ore. This practice commingles the products of combustion and the sulphur gas, so that the latter is not available for acid making. Further, it is considered financially risky in this district to make a greater investment than necessary, with short-lived gas pools controlling the situation.

Coal-burning plants, on the other hand, have a much higher investment cost both on account of the need for gas-producer equipment and the necessity for using expensive muffled roasters, or kilns, so as to avoid the relatively high volatilization loss of zinc when burning coal in a "reverberatory" style of working. Since these kilns prevent the commingling of the products of combustion and the bases resulting from the oxidation of the ore, the latter may be used for making sulphuric acid, thus giving us what are called zinc-acid plants.

The sulphur-bearing zinc ores of this country are found mainly in Missouri, Wisconsin, Montana, Colorado, Tennessee and California. With the exception of Tennessee the zinc ores available to our reduction plants came mainly from west of the Mississippi, and freight rates settled the advantageous smelting points near cheap coal supplies in Illinois. The pre-war American market could absorb only a limited amount of spelter, and exportation was impracticable because about 60 per cent of the world's consumption of the metal was more cheaply furnished by Australian ores finding cheap water transportation to Belgian smelters. Zinc acid did not begin to cover the requirements of the United States, but even if the demand for spelter had been such that there could have been a greater coincident production of sulphuric acid, it was practically impossible for a commodity of this low value to be transported any great distance by railroads under existing freight rates. That there have been gradual changes in the geographical location of zinc-acid plants should be noted in a general panoramic view, for two zinc-acid makers have invaded the Pittsburg district with very large plants, one of them formerly a very large customer of acid manufacturers, and two others

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are now operating in close proximity. Ores from Australia, not being utilized by the Germans just at present, are finding a very satisfactory market at these Eastern smelters. It would seem as if ocean freight rates are such as to allow of a continuation of this business even in normal times.

In the United States brimstone acid is usually the most expensive; that made from lump pyrites is probably second in cost; that from "pyrites fines" is third; while zinc acid is the cheapest. The metallurgy of zinc makes demands upon equipment investment and per-ton cost of handling which is the greatest of any of the ordinary metals. It makes technological demands which leaves the cost of by-product sulphuric acid anything the policy of the company may wish it to be. It is a metallurgical fact that the losses of metal in open roasting as opposed to muffled roasting, using producer gas from coal as fuel, are such that muffled roasting would be desirable even if the resulting sulphur fumes were not utilized. Since muffled roasting in this case is a necessity to avoid volatilization of zinc, a sulphuric acid plant which demands a relatively clean and strong gas naturally follows. Since the roasting has to be done on such a high-priced commodity as high-grade zinc concentrate, it ordinarily really matters little whether the gases are handled to make sulphuric acid or not. The factor that controls this in normal times is that such gases turned into the atmosphere of communities where zinc smelters usually are located would be a nuisance. Other things being equal, it is preferable to avoid trouble. While this fear of committing a nuisance has been a very valuable asset to the United States under war conditions, it will cause some concern when normal times come, because, in order to handle the ores, the gases will be produced and the acid will be made. Some strenuous endeavors will have to be made by sales forces, and, incidentally, traffic departments working with the railroads, in an endeavor to dispose of this by-product acid into a territory which may be expanded in proportion to the expansion that the zinc smelting industry has undertaken as a result of the war stimulus.

Acid from Other Metallurgical Sources

There has been no material increase of acid capacity in any other metallurgical line than that of burning pyrites bearing valuable metals and that of zinc blende. It should not be considered, however, that pyrites and blende, along with brimstone, are the only sources of suitable gas for acid manufacture. Two of our large copper smelters have been making large tonnages of acid from the fume evolved from blast furnaces. These two companies have used what is called semi-pyritic smelting. Since the war started two installations have been completed where copper ores will be used as the source of supply for the acid gases. Both of these are using easily roasted, high-iron, low-copper, sulphide minerals in a roasting process that is easily comparable with that of ordinary clean iron pyrites.

With the demand for relatively clean and concentrated gas there cannot be much hope for the utilization of lean, dirty gas produced from ores ordinarily handled in lead smelting practice. This would not apply, of course, where part of the ore used could be iron pyrites relatively free from lead. It should be appreciated that the satisfactory roasting of ores for acid making is a far different proposition than roasting merely to create a desired metallurgical condition. In acid roasting no large excess of air may be allowed to pass through the roaster, and this restriction permits the development of high temperatures which, in the case of leady ores, causes the volatilization of a large part of the metal, whereas in a metallurgical roast large volumes of air are caused to pass through the roaster, so cooling it down to a point which makes such roasting easily manageable.

The large part of the United States demand for acid comes from those states near the Atlantic Ocean and those Southern states in which the soil demands fertilization. To take care of this numerous plants were operated in these areas by burning iron pyrites solely for the purpose of furnishing gas for acid making, using varieties from the sources mentioned before which roast very easily, either in lump burners or in mechanical fines furnaces. By so doing the process of acid making is very simple indeed.

In general it may be said that sulphuric acid can be most easily made by using brimstone and that the difficulties of manufacture increase in the following order:

(a) Burning clean pyrites in lump burners.

(b) Burning clean pyrites in mechanical furnaces.

(c) Roasting sulphide mixtures (i. e., mixtures of iron, lead, zinc, etc., with sulphur).

(d) Dead-roasting zinc blende in kilns; and, finally,

(e) Utilizing waste sulphur gases from metallurgical operations with the likelihood that dilution and obnoxious volatile constituents will have to be fought.

Where pyrites was bought for acid-making it was usually purchased on the basis of a price per unit of sulphur, which, at the various points of consumption before the war, probably would average eleven cents. Under the "price per unit" system the given price applies to each per cent of sulphur in the pyrites, and the price per ton of ore is accordingly determined by multiplying the unit cost by the percentage of sulphur as found by analysis.

The "cinder" or roasted ore resulting from burning pyrites was usefully applied in one of three ways: The Spanish cinder was shipped to a chloridizing-roasting copper-leaching plant operated by one of the large acid manufacturing companies; the barren cinder was sent without any further treatment to iron blast-furnaces, where it was more suitably prepared for iron manufacture by being further desulphurized to 0.2 or 0.3 per cent sulphur by blast-roasting; or, was used for road building, complete fertilizer filling, etc. A number of small acid plants were not and are not yet storing this material, which is apparently waste to them, but this practice should not be continued, because there will be a time not far distant, if it is not already here, when a metallurgist can suggest a course of procedure which will show a profit.

Brimstone vs. Pyrites

The American demand for sulphur has increased, and strenuous times are at hand at this writing for reasons already given. With so many manufacturers already having changed from pyrites to brimstone burning, it would be remarkable were our brimstone supply elastic enough to take over all the additional load. We are to be congratulated that our Union Sulphur and Free-

port Companies have been able to expand their former output many times.

There are brimstone deposits in Wyoming, near Cody and Thermopolis, but the rock does not occur in large quantities in the individual pockets, nor is it of a sufficiently high grade. It will probably average 30 per cent sulphur in workable deposits.

The substitution of brimstone for pyrites in a number of plants that have been burning the latter has enabled these manufacturers to produce a greater tonnage of acid from a given sized unit. When brimstone is used as a source of sulphur dioxide, the plant investment per ton of acid produced is far less, other things being equal, than when acid is made from pyrites. The reason for this is that the burner construction is much simpler, the gas resulting from brimstone is far richer and so demands less chamber space per pound of sulphur burner than in the case of pyrites. In burning the latter, part of the oxygen entering the roaster, or the lump-burner, as the case may be, is consumed in oxidizing the iron that is a constituent of pyrites. The nitrogen, of course, that enters with this oxygen, passes on with the sulphur dioxide gas that results from the oxidation of the sulphur and acts as a diluent in the burner gas. With brimstone there is no other material to be oxidized, and therefore the air that passes in for oxidation furnishes only a sufficient amount of oxygen for the brimstone itself. Burner-gas from pyrites may carry 8 per cent SO_2, whereas that from brimstone may run 12 per cent.

In normal times, and even under the present circumstances, the sulphur in brimstone is more expensive than that in pyrites, but, on account of the lack of boats for the transportation of Spanish pyrites and the accident to the large Virginia supply, the manufacturer has little option to do otherwise than buy the more expensive brimstone. One ton of brimstone will make practically three tons of 66 deg. Be. acid, or four tons of 60 deg. Be. acid. If the brimstone is sold at a cost approximating $36 a ton delivered, it may be easily computed that this cost alone against 66 deg. acid is approximately $12 per ton, and that the cost of the brimstone in 60 deg. acid is $9 per ton. The increased investment and operating cost per ton of 66 deg. acid made from pyrites as against brimstone is approximately $2 per ton. This would compare now with a pyrites price of approximately 32 cents per unit, calculating for the roaster losses. The differential between brimstone and the sulphur in pyrites is even now, therefore, great enough to permit of the use of pyrites, even though less acid is made in a given plant and even though the plant investment costs more per ton, as rarely is 30 cents per unit asked. In a "speed-up" policy our Government is asking for as large a production as possible, so brimstone is now used as far as possible for patriotic as well as commercial reasons.

The Contact Process

A decade or so ago there was quite a controversy among acid makers on the relative merits of the contact and chamber processes. It was even predicted at that time that the chamber process could not long survive and that the contact would be the only one used.

The situation in the country developed as follows: The General Chemical Company secured the American rights for the "Badische" contact process, the New Jersey Zinc Company for the "Grillo-Schroeder" process, Mr. Wilke of Buffalo, N. Y., for the "Mannheim" process and the Merrimac Chemical Company for the "Tantelewski" process. Sulphuric acid production continued to be largely the result of the use of the chamber process for the reason that the plan of licensing was usually made both onerous and annoying, onerous in that the royalties exacted were relatively heavy, more particularly on the stronger grades of product, and annoying for the reason that most licenses proposed were in such form that the licensor would have every opportunity of learning exactly what the licensee's business amounted to. Since it was not deemed advisable to place this information in the hands of competitors, there was a disinclination on the part of most manufacturers to use the contact process.

Later on, as a result of European litigation, the American rights for all of the four contact processes virtually passed into the control of one company, whose American representative is the General Chemical Company.

General Plant Equipment

With acid making tending to pass over to various ore smelters and with fine concentrates from flotation mills and their reduction plants creating clouds of dust in the roaster gases, much money has been spent in an endeavor to adapt the Cottrell precipitation process to handle the gases used for acid manufacture. In the chamber process it is desirable to have the roaster gas remain as hot as possible in its passage to the Glover tower. In roasting material containing iron a small percentage of the sulphur is converted catalytically, under the effect of the roast, to sulphuric anhydride, and this, of course, will combine with the moisture present in the air admitted to the gas, with the result that sulphuric acid will be precipitated in flues if the gas becomes cool. To maintain a lot of metallic parts at red-hot temperature, to avoid the corrosion that takes place when the temperature drops, and to maintain a delicate equipment in commission when either one or the other condition is likely to prevail present difficulties, particularly when one is trying also to prevent the leakage of voltage which is not within the realm of ordinary usage. This has caused the Cottrell scheme to be abandoned in the acid works where it was tried. Some good dust-collector designs, however, have been perfected and are so simple that these may be placed in the hands of the ordinary operator. The manufacture of sulphuric acid by either process, the contact or the chamber process, demands an approximation to that condition which we call "fool-proof," and with this idea the Cottrell does not comply.

Mechanical roasters of the McDougall type have been greatly improved in their ability to avoid "lost time." Numbers of modifications of design permit of use in almost any wide range of metal content in sulphide ores and products. In acid manufacture the ability of this type to conserve heat has driven all but the old Hegeler kiln (for dead-roasting zinc blende) out of the market, and the near future will no doubt see this type slowly displacing even the Hegeler. The construction of the old fashioned lead tower in chamber plants is rapidly giving away to far cheaper masonry designs, and the old crockery pipes, containers, cocks and pipelines to the silicon-iron castings.

Variety of Demand for Sulphuric Acid

I can recall no explosive (with one exception, black powder) which does not depend upon sulphuric acid in some form for its manufacture. Of course, all explosives demand nitric acid or nitrates in their manufacture. To take up the water both of the original nitric acid and that formed from the nitration reaction demands the presence of some dehydrating agent. The one found best suited is sulphuric acid. The explosives manufacturer, therefore, is interested in strong sulphuric acid to make nitric acid and as a dehydrating agent. As a result of the war demand there was a tremendous increase of devices for the concentration of the weak acid, resulting from the chamber process, or which is a by-product itself of explosives manufacture. The result is that a great deal of sulphuric acid concentrating equipment was installed in explosives plants, and many hundreds of tons of this material were used to make an excess of nitric over and above any pre-war requirements.

It would be interesting to trace back the effect of the war upon numbers of industries. Take the automobile industry, for instance, and its effect upon the sulphuric acid industry. It is a fact that money made as a result of the stimulus of the war upon manufacturing in the United States has made it possible for a greater percentage of the people to buy automobiles, and these machines demand, of course, more crude oil for fuel and for lubrication. This increased demand along with that of the increased use of oil in the industrial operations for building the cars has resulted in an increased use of the oil resources of the United States. Since sulphuric acid enters largely into the refining of these oils, the acid industry has been called on to measure up to this demand.

If the Southern complete-fertilizer maker had been able to secure potash from some place other than Germany, and southern fertilization had been practised as in normal years, there would have been in the aggregate such a demand for sulphuric acid that there would have been no hope of meeting it. If it had not been for the aid of the Southern fertilizer manufacturer in diverting his acid output from the fertilization of soil to the needs of other industries we would not have had our present industrial activity. The Southern soil, however, cannot weather more than a few seasons of partial fertilization. The increased demand for cotton, both as a result of industrial activity and the manufacture of smokeless power and gun cotton, has forced the Southern cotton grower to wonder what will happen in the coming year if he fertilizes so little as he has for the past two or three years. The three plant foods that are essential in a fertilizer are available potash, available nitrogen and available phosphorus. The only real potash comes from the Stassfurt mines of Germany, although the United States is now producing some low-grade material in Nebraska. We of the United States have the real supply of phosphate rock and in normal times are easily able to make more than enough sulphuric acid to take care of any demand that may be made of its acidulation. With the potash supply from Germany cut off and with the acid supply utilized some other way, the Southern cotton grower has been compelled virtually to do without. This year he is beginning to think that something strenuous should be done, because high prices of cotton and food make fertilization imperative for the reason that a good yield per acre cannot be hoped for unless some potash and acidulated phosphate rock are supplied to the soil. This in turn will stimulate a further intensified production of acid, if such is necessary, and I rather expect this demand for fertilizer will keep on intensely even though the war will have removed the demand for acid for the making of explosives. In other words, after allowing Southern soil to go for two or three years it will probably take more than the normal yearly supply to rehabilitate it.

Sulphuric acid is one of the raw materials entering into the manufacture of most other chemicals, notably nitric acid, hydrochloric acid, salt cake (which is used in the plate-glass business), blue vitriol, green vitriol, almost all organic preparations, artificial leathers, combs, reclaimed rubber, electrical insulators, etc., and one could indefinitely elaborate upon the effect that new industries and the stimulation of increased activities in all lines of business have had on its production. Suffice it to say that it has all resulted in causing an increase of plant capacity so greatly in excess of what apparently can be used after the war is over that some manufacturers are already concerned. Operators will consider it advisable to keep plants running as long as possible before shutting down since it is well known that an idle sulphuric acid plant deteriorates much more rapidly than does one that is running.

Future of the Industry

For the future, I think the general trend will be to relegate acid manufacture to those engaged in the metallurgical industry. I think there will be a gradual decline in the practice of pyrites-burning, and incidentally brimstone, for the express purpose of making sulphuric acid. From an economic point of view this would be probable for the reason that it would seem undesirable for one part of the country to be wasting thousands of tons of available sulphur gas while another part is spending millions of dollars for the purchase of sulphur-bearing material, when a large part of the latter comes from a greater distance than would the acid if it came from the point at which it is being wasted. If we could properly impress the railroads with the advisability of hauling this commodity at rates more comparable with those of other commodities used in equal tonnages and having approximately equivalent values, we might secure a better commercial condition. If this equalization is not practicable, I think there will be a general trend of acid-consuming industries toward the territory at which sulphuric acid may be cheaply produced as a by-product in a manner similar to the trend of industries demanding cheap electrical power to the Niagara Falls district.

Denver, Col

Shale Oil Reserve for Navy.—In the annual report of the Director of the Geological Survey, just made public, attention is called to the creation of two naval oil reserves in Colorado and Utah. The Survey has explored large areas in Colorado and Utah that contain immense deposits of such shales, some of which carry 30 to 50 gallons of oil to the ton. The Colorado reserve created for the Navy contains 45,440 acres, and the one in Utah 86,584 acres.

The Influence of Heat Treatment

On the Electrical and Thermal Resistivity and Thermo-Electric-Potential of Some Steels*

By EDWARD D. CAMPBELL and WILLIAM C. DOWD

THE principal object of the present investigation—which is far from being complete—was to conduct a preliminary study of the correlation of electric and thermal properties of steels in the light of the solution theory if accepted in the full sense of the term.

Although an apparent connection between thermal and electrical conductance in metals had previously been noted by Forbes, it was the systematic work of Wiedeman and Franze in 1854 which demonstrated the relationship was probably a definite one. If this were the case it would be reasonable to expect both electrical and thermal resistivity in metals might be due to the same atomic or molecular mechanism. Although numerous investigators studied the relation existing between electrical and thermal resistivity in metals subsequent to Wiedeman and Franze's publication, it was the exhaustive work of Jaeger and Diesselhorst which demonstrated that the ratio of the electrical to the thermal resistivity is approximately constant for pure metals, but does not hold equally well for impure metals or alloys. In 1897 Schulze[1] measured the thermal and electrical conductivities of five carbon steels and one manganese steel, and showed that the Wiedeman and Franze law did not hold in the case of these metals. It is now generally conceded that the Wiedeman and Franze law—that is, the ratio of the electrical to the thermal resistivity in absolute units—holds quite closely for pure metals, being about 6.5×10^{-10}. It does not, however, hold very closely for impure metals or alloys, although in general any marked change in electrical resistivity is accompanied by a corresponding change in thermal resistivity. During the past twenty years physicists have carried out a great number of experiments in order to determine with increasing degree of accuracy the correlation of electrical and thermal resistivity in metals, with special view to the influence of the temperature at which the measurements were made on this relationship. In almost all this work metals or alloys of metals other than iron were employed. Very few, if any systematic measurements of the thermal resistivity of steel have been made, although the fact that there is a close relationship between the chemical constitution and electrical resistivity of steel has been recognized for more than fifty years, and has served as a basis for many researches.

Although the solution theory of metals, as it is now termed, was first advanced more than a century ago, to the great majority of physicists and metallurgists the term is almost a meaningless phrase, since they still refuse really to accept as a mental concept the essential unity of mechanism of metallic and aqueous solutions. They all recognize and take into account the part played by the solvent as differentiated from that played by the solute in ordinary solutions, and yet, when studying the properties of metallic solutions, many of them refuse to recognize the essential unity of mechanism, and make little or no effort to differentiate between the part played by the solvent and that by the solute. It would seem entirely possible that, if metallic solutions were regarded from exactly the same viewpoint as ordinary solutions, reasonable explanation for many well-known phenomena might be found which cannot be satisfactorily explained in any other way.

In 1915 one of the authors[2] gave experimental evidence to substantiate the conception that total electrical resistivity of steel must be considered as made up of two components—first, that due to the solvent, and, second, that portion due to the carbides in solution; the effect of these latter on the electrical resistivity being proportional to the concentration of the carbides actually in solution. It was there suggested that, as in aqueous solutions, it is the molecules in solution which are capable of reacting with different forms of energy, and consequently the electrical resistivity would be dependent on the molecular concentration of the carbides in solution, since by their reactivity these carbides would cause electrical energy to disappear as such and reappear in the form of heat.

In a later paper[3] the dependence of the electrical resistivity on the concentration of the carbides in solution was confirmed, and it was further shown that if carbides are the only solutes present in noticeable amounts the thermo-electric potential due to dissolved carbides is a function of the concentration. In these same papers it was further shown that electrical conductance is almost entirely through the solvent, while electrical resistivity is only in part due to the solvent, frequently as much as 80 per cent or more of the total resistivity being due to the solutes in solution.

Experimental

The experimental bars used were all machined down to a uniform size of 6 mm. square by 15 cm. in length from stock samples of larger bars furnished by the courtesy of the same companies which have supplied us with bars on our previous work. The composition of the steels used in the present research is given in Table I.

In annealing the steels used, a number of sample bars were usually packed in an electrically heated furnace in such a way as to avoid oxidation, and the temperature raised overnight to that stated as the temperature from which each sample was annealed, after which the furnace was allowed to cool for twenty-four hours and

*A paper read at the annual meeting of the Iron and Steel Institute, London, Sept. 20, 1917.

[1] Annal. Phys. Chem., vol. 63, p. 23, 1897.

[2] *Journal of the Iron and Steel Institute*, 1915, No. II, p. 163

[3] *Journal of the Iron and Steel Institute*, 1916 No. II, p. 268.

TABLE 1—COMPOSITION OF STEELS.

Steel.	Carbon per Cent.	Manganese per Cent.	Phosphorus per Cent.	Sulphur per Cent.	Silicon per Cent.	Copper per Cent.	Nickel per Cent.	Chromium per Cent.
IN1	0.018	0.016	0.005	0.018		0.018		
H57	0.50	0.11	0.010	0.020	0.17			
INC	1.184	0.416	0.005	0.018		0.018		
C5	0.945	0.189	0.013	0.016	0.155			
H1	0.48	0.67	0.007	0.019	0.16		3.45	
MN	0.326	0.405	0.013	0.025	0.162		4.48	
H6	0.14	0.44	0.009	0.008	0.11		4.12	1.61
SN1	1.110	0.40	0.020	0.038	1.20	0.06	0.31	0.548
SN3	0.104	0.122	0.03	0.025	3.649			
MN1	1.150	1.157	0.055	0.023	0.25			

the large sample bars removed. It was from the sample bars thus annealed that the small experimental bars used for quenching were machined. All temperatures, whether of annealing or quenching, were measured by means of standard platinum-rhodium thermocouples standardized at intervals against the melting point of pure silver taken at 961 deg. C.

The method of hardening the small bars was essentially the same as that employed in this laboratory for some years and described in detail in 1915.[4] The bars to be quenched where suspended in an electrically heated furnace so designed that, no matter how long they were kept in the furnace, there was no oxidation, and carburization, if occurring at all, did not exceed 0.02 per cent. The bars were kept in the heated chamber as a rule one hour, the temperature being measured by a thermocouple placed 2 to 3 mm. from the bars under treatment. The quenching bath was a large volume of ice-water, and, as in our previous work, the time required a bar from the furnace to the quenching bath was a little less than one second, the same amount of time being required to cool the bar from the quenching temperature to below a red heat. Experience in this laboratory has tended to show that bars which are perfectly clean and bright cool somewhat more quickly on quenching than the same sized bars which have been heated in a fused salt bath. These latter, on withdrawing from the heating bath, are covered with a thin film of fused salt which appreciably retards the cooling effect of the water. Enough bars of each kind of steel were quenched to enable the specific resistivity and thermo-electric potential to be measured at the same time. Thermal resistivity was measured on one of these bars after the other measurements had been made. After all the bars had been quenched they were carefully polished and the measurements of specific resistivity, thermo-electromotive force, and thermal resistivity, made with no more delay than was necessary. Numerous experiments in this laboratory have shown that, on account of the instability of the solid solution produced by quenching steel in cold water the specific resistivity and correlated properties will fall off very appreciably even at room temperature within a comparatively short time.

The specific resistances were measured in all cases on bars kept immersed in an oil bath and maintained at a constant temperature of 25 deg. C. The method of determining specific resistance was the same as that heretofore employed, that is, by measuring the fall in potential between knife-edges clamped to the bar 10 cm. apart, while a current of constant density was flowing through the bar.

On account of the rapid change in chemical constitution of hardened steel with increase of temperature it was thought best to make the measurements of specific resistances, thermo-electromotive potential, and thermal resistivity without allowing the temperature of the bars at any time to exceed 35 deg. C. or 40 deg. C. The thermo-electromotive force measured, therefore, was that due to the temperature gradient between 0 deg. C. and 25 deg. C. The method employed was a modification of the one used a year ago and described in detail in one of our previous papers.[5] In the method used in the present work three bars of the same steel and subjected to the same heat treatment were clamped together to form a triple compound bar, to the ends of which were attached, by means of pure iron clamps, the annealed ingot iron leads connecting the ends of the compound bar with the galvanometer by means of which the potential was measured. One end of the compound bar was maintained, as in our previous work, at 0 deg. C. by means of crushed ice, while the other was immersed in the same oil bath as that used for specific resistivities, which was maintained at 25 deg. C. Thus the thermo-electromotive force, measured and expressed in microvolts, represents the difference in thermo-electromotive potential of the steel in question and pure iron over the temperature gradient from 0 deg. C. to 25 deg. C.

As the work herein described is in a sense a preliminary study of the correlation of electrical and thermal resistivities without any attempt to determine the absolute relationship, the thermal resistivities so far determined have all been relative, that of pure ingot iron being taken as unity. It is hoped that later new determinations of thermal resistivities will be made with improvements in the apparatus which will enable such measurements to be made under more favorable conditions, and with a higher degree of precision, so that the results may be reduced to absolute units. The method employed of measuring the relative thermal resistivities herein given was one of the stationary temperature type, the technique of which was developed under the direction of Dr. Carelton V. Kent of the Department of Physics. The detailed description of this method of Dr. Kent is given in the *Physical Review* of 1917.

The method of determining the relative thermal resistivities is briefly as follows: The bars, 6 mm. square and 15 cm. in length, are provided with two holes a little more than 1 mm. in diameter and 4½ mm. in depth, one hole being 5 mm. from the cold end of the bar and the other 10 cm. from the same end. These holes are for the insertion of fine copper-constantan thermocouples, by means of which the difference in temperature between each of the holes and the surrounding space is measured. The holes were filled with paraffin oil before inserting the thermocouples; a better thermal contact being thus obtained between the couple and the steel than when the oil was not used. About 3 cm. of one end of the bar was inserted in a small heating oil by means of which the temperature of the bar at the hot end could be easily raised and maintained constant for any desired length of time. The bar, supported in the heating coil and with thermocouples in position, was inserted into the center of a heavy steel

[4] *Journal of the Iron and Steel Institute*, 1915, No. II, p. 164.

[5] *Journal of the Iron and Steel Institute*, 1916, No. II, p. 268.

cylinder, 20 cm. inside diameter and 40 cm. long, and closed at the inner end with a heavy steel plate. This steel cylinder was, in turn, boxed in, in order to avoid local air currents. The mass of the metal—something more than 20 kilograms—was sufficient to maintain reasonable constancy of temperature throughout the interior during a given experiment. After a bar whose thermal resistivity was to be measured had been inserted into the steel cylinder, a current was turned on through the heating coil until the thermocouple showed a rise of about 10 deg. C. The copper-constantan thermocouples used were made of very fine wires, each being calibrated against a standard thermometer. The couples gave a deflection of about 6 mm. per each degree, so that temperatures could be readily measured to within less than 0.05 deg. C. Since all bars were of the same dimensions, the thermocouple holes were the same distances from the cold end in every case, and the temperature of the higher point of measurement was substantially constant in all cases, the difference in temperature at the cold and hot points of measurement must have been directly dependent upon the thermal resistivities of the bars. Usually from 1½ to 2 hours were required for the system to come to equilibrium. When this had been attained, the ratio of the temperature difference at the hot and cold ends of the bar was calculated. Dr. Kent has shown that the ratio $\frac{\theta_1}{\theta_2} = \cos aL$ in which simplified equation $a = \sqrt{\frac{hp}{cq}}$ where h is the heat lost to the enclosure from 1 sq. cm. of the surface per degree excess temperature, p is the perimeter, c is the conductivity and q is the cross-section of the bar. From mathematical tables giving hyperbolic functions aL may be found from the experimentally determined temperature ratio $\frac{\theta_1}{\theta_2}$. Since we are interested in the reciprocals of the conductivity or the resistivity, the relative resistivities may be easily found from the (aL) as h, p, q, and L the distance between the hot and cold points of measurement, are the same for each bar. The resistivities would, therefore, be directly proportional to the square of the (aL).

The results of the measurements of the specific resistance at 25 deg. C., of the relative thermal resistivity, and of the thermo-electromotive force of the nine steels in the annealed condition, are given in Table II, in which the steels are arranged in order of increasing specific resistance. In this table is also given the specific resistance of the pure ingot iron, which is taken as unity in the determination of relative thermal resistivities and which is also used in opposition to the different steels when determining the thermo-electromotive potential. The small numbers in parentheses following the names of the steels as given in Table II serve to identify the points corresponding with each steel, as shown graphically in Figs. 1 and 2.

TABLE II.—TABLE SHOWING SPECIFIC RESISTANCE RELATIVE THERMAL RESISTIVITY, AND THERMO-ELECTROMOTIVE POTENTIAL OF ANNEALED STEELS.

Steel.	Temperature of Annealing.	Specific Resistance in Microhms.	Relative Thermal Resistivity.	Thermo - Electromotive Potential against Ingot Iron in Microvolts.
	Degree C.			
IN1(1)	778	10.64	1	...
H57 (2)	903	15.28	1.25	116
IN6 (3)	960	15.90	1.35	90
C5 (4)	903	18.05	1.47	128
H1 (5)	700	25.16	1.99	310
M8 (6)	...	25.36	2.03	371
H6 (7)	718	32.24	2.38	232
SN1 (8)	950	41.58	2.84	362
SN3 (9)	985	53.37	3.17	556
MN1 (10)	810	54.25	3.78	334

In Table III are given the corresponding measurements made on the same steels as those given in Table II, but with the steels in the quenched or hardened condition. The steels are again arranged in order of increasing specific resistance, but it will be noted, from the small figures in parentheses following the name of each steel, that the order of arrangement of

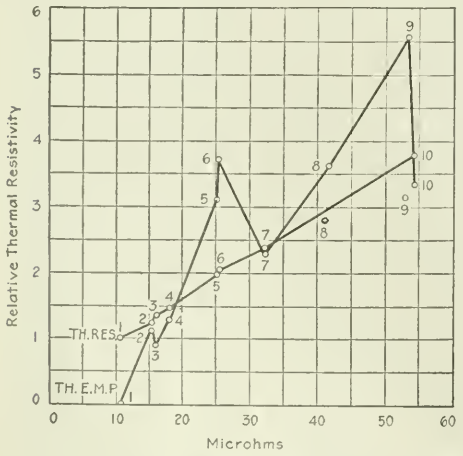

FIG. 1.—THERMAL RESISTIVITY AND THERMO-ELECTROMOTIVE POWER OF ANNEALED STEELS

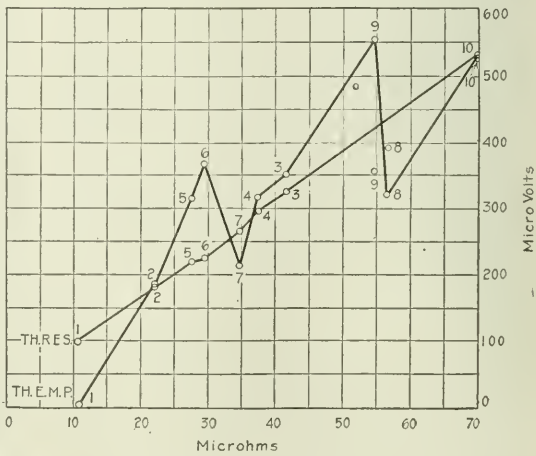

FIG. 2—THERMAL RESISTIVITY AND THERMO-ELECTROMOTIVE POWER OF QUENCHED STEELS

the steels in the hardened condition is quite different from what it was when the steels were annealed.

In order to bring out the correlation of the thermal and electrical resistivities as influenced by chemical constitution and heat treatment, the results of the measurements given in Tables II and III are shown graphically in Figs. 1 and 2. In these the specific resistances in michroms are shown on the abscissæ, while the corresponding relative thermal resistivity and thermo-electromotive potentials are shown on the ordinates. It will be noted that the curve of relative thermal resistivity is approximately a straight line except for two points, 8 and 9, of the steels SN1 and SN3, both of which are high silicon steels, the silicides apparently giving a distinctly higher ratio of electrical to thermal resistivity than do carbides or other solutes.

TABLE III.—TABLE SHOWING SPECIFIC RESISTANCE, RELATIVE THERMAL RESISTIVITY, AND THERMO-ELECTROMOTIVE POTENTIAL OF HARDENED STEELS.

Steel	Temperature of Quenching.	Specific Resistance in Microhms.	Relative Thermal Resistivity.	Thermo-Electromotive Potential against Ingot Iron in Microvolts.
	Degrees C.			
IN1 (1)	Annealed	10.64	1	...
H57 (2)	902	22.08	1.85	186
H1 (5)	902	27.74	2.22	318
M8 (6)	830	29.72	2.27	...
	900	...	...	368
H6 (7)	830	34.77	2.68	216
C5 (4)	830	37.41	2.99	...
	902	...	...	320
INC (3)	830	41.64	3.27	...
	902	...	...	352
SN3 (9)	902	54.72	3.57	556
SN1 (8)	830	56.38	3.93	324
MN1 (10)	902	69.80	5.35	534

A study of the data given in Tables II and III, and of the curves shown in Figs. 1 and 2, reveals some interesting relationships, especially if viewed in the light of the solution theory of steel accepted in the full sense of the word. If steel is regarded as made up of a solvent and solutes, we may get an approximate idea of the relationship of that portion of the electrical resistivity due to solutes, to that portion of the thermal resistivity to solutes by subtracting from the total specific resistance of pure iron (10.64), and, from the total relative thermal resistivity, that of pure iron (1.00), and then finding the ratio of the electrical resistivity to the relative thermal resistivity. The ratio of the electrical resistivity to its relative thermal resistivity of pure iron would, of course, be 10.6. If, in the case of the annealed steels, we calculate by the method above just suggested—the ratio of the electrical resistivity to the relative thermal resistivity—we find this varies from 14.3 to 19.7 in the case of SN3, in which the solute is almost entirely silicide. In the case of the hardened steels the ratio of the electrical resistance to the relative thermal resistance due to solutes varies from 13.4 to 17.4, the highest ratio again being due to that of SN3, containing the highest concentration of silicides. These ratios are all noticeably higher than the ratio found in the case of pure iron solvent and confirm what has been known for many years—that the Wiedeman and Franz law does not hold in the case of impure metals or alloys, the electrical resistivity of such metals increasing more rapidly than the thermal resistivity. In all the steels under examination the effect of quenching has been to increase both the electrical and thermal resistivity, the extent of this change being closely connected with the percentage of carbon in the steels. This would be expected, since it is the carbides which precipitate from solution when the steel is annealed and again pass into solid solution when heated above Ac3 just before quenching.

In 1916[4] a hypothesis to account for electrical resistivity in steels was advanced. This hypothesis assumed the essential unity of mechanism of solid solutions and of aqueous solutions, and attributed that portion of the total specific resistivity due to carbides in solution to the transformation of electrical energy into heat, this transformation being due to the fact that it is those molecules in solution that are most reactive toward any form of energy. If heat is assumed to be made up of two forms of motion, one portion being electronic and the rest atomic or molecular motion, we might easily find a reasonable explanation for the correlation between electrical and thermal resistivities based on the solution theory in the full sense of the word. If molecules of solutes in solution are capable of reacting with electrical energy and transforming a portion of this electronic motion into atomic or molecular motion, thus producing electrical resistivity, it would be only reasonable to expect that the same molecules in solution which could transform electronic motion of electricity would also be capable of transforming that portion of heat which exists as electronic motion into atomic or molecular motion. Under this conception we would expect a close relationship between the electrical and thermal resistivities of steel, since they both become dependent upon the chemical constitution.

When carbides are the only solutes present to any considerable extent it was shown in the paper before referred to that there is a parallelism between the thermo-electromotive potential of these carbides and the specific resistance, both being dependent on the concentration of the carbides in solution. From the curve of the thermo-electromotive potential shown in Figs. 1 and 2 it will be evident that the thermo-electromotive potential is dependent upon the chemical composition of the solutes as well as on the concentration. Under the conception of the essential unity of mechanism of metallic and aqueous solutions, the assumption that the thermo-electromotive potential of solutes in solid solution is exactly analogous to the solution tension of electrolytes in aqueous solution would offer a simple explanation for the changes in thermo-electromotive potential due to differences in chemical composition and heat treatment. If a cell be set up with an aqueous solution of a single electrolyte A, the electromotive force of such a cell will be dependent on the chemical composition and concentration of the electrolyte. If a second cell be set up with an electrolyte B, of higher solution tension than A, the electromotive force of the second cell will be higher than that of the first for a given concentration. If a cell be set up with a mixture of these electrolytes, A and B, the electromotive force of such cell will not be additive, but will be intermediate between that of A and B, never reaching as high as when B alone is present. An exactly analogous change will be found in the thermo-electromotive potential of steels when the concentration of the solutes in solution is changed by heat treatment. When the thermo-electromotive potential of the solute

[4] *Journal of the Iron and Steel Institute*, 1916, No. II, p. 8

in solution, other than carbides, is higher than that due to carbides in solution, the thermo-electromotive potential of such steels in the hardened condition tends to be lower than that of the same steel annealed, since in the annealed condition the carbides are very largely precipitated. This is most strikingly illustrated in case of SN1, where we find a distinct drop in thermo-electromotive potential brought about by quenching, although the specific and thermal resistivities are both markedly increased due to the increased concentration of the solutes in solution.

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Chemical Alliance Succeeds Chemical Committee of Council of National Defense

With the dissolution of the committees of the Council of National Defense, a plan was submitted to the authorities in Washington, whereby the Chemical Alliance, Inc., would take over some of the work of the Committee on Chemicals and its various sub-committees. The Chemical Alliance was originally formed last August to take up certain matters in connection with fertilizers and pyrites importation.

The officers and directors of the Chemical Alliance, Inc., were all members of the Chemical Committee.

Rather than resolve the various sub-committees of the Chemical Committee into separate and distinct trade committees, it seemed advisable to the Chemical Committee at the time of the dissolution of Council of National Defense committees to try and hold its organization intact, and the Chemical Alliance, Inc., seemed to offer the best medium for the accomplishment of this purpose.

Dr. William H. Nichols, chairman of the Committee on Chemicals and president of the Chemical Alliance, Inc., resigned from the presidency of the Alliance, and Horace Bowker, vice-president of the Chemical Alliance, Inc., was elected president. Henry Howard, chairman of the executive committee of the Manufacturing Chemists' Association, was elected vice-president. J. D. Cameron was elected treasurer and secretary pro tem. The directors of the Chemical Alliance, Inc., are as follows: Dr. William H. Nichols, General Chemical Company, New York City; Horace Bowker, American Agricultural and Chemical Company, New York City; E. R. Grasselli, Grasselli Chemical Company, Cleveland, Ohio; J. D. Pennock, Solvay Process Company, Syracuse, N. Y.; William Hamlin Childs, The Barrett Company, New York City; D. W. Jayne, The Barrett Company, New York City; C. H. MacDowell, Armour Fertilizer Works, Chicago, Ill.; C. G. Wilson, Virginia-Carolina Chemical Company, Richmond, Va.; John J. Riker, E. D. & J. J. Riker Company, New York City; F. A. Lidbury, Oldbury Electro-Chemical Company, Niagara Falls, N. Y.; A. D. Ledoux, Pyrites Company, Ltd., New York City; Henry Howard, Merrimac Chemical Company, Boston, Mass., and Edward Mallinckrodt, Jr., Mallinckrodt Chemical Works, St. Louis, Mo.

The offices of the Alliance, Inc., for the present will be 538 Woodward Building, Washington. Telephone, Main 9946.

The sub-committee on fertilizers of the Committee on Chemicals now becomes the committee on fertilizers of the Chemical Alliance, Inc., with offices and telephone number as heretofore.

The Chemical Alliance, Inc., is now not a Government committee, but acts in an advisory capacity to the Government in collecting data, making recommendations, etc. The actual buying of chemicals, explosives, etc., is in charge of Mr. L. L. Summers, whose office is in the Council of National Defense Bldg. This arrangement should work out very satisfactorily to all concerned.

Acidity Determination in Water, Leach Liquors, Mine Waters, Etc.

By James J. Rankin
Assistant Chemist, Research Dept., Phelps Dodge Corporation

THE following method for determining acidity in the presence of sulphates of ferrous and ferric iron, copper, aluminium and manganese is new and is, we believe, much more accurate than the usual titration methods.

The objection to titrating solutions containing ferric iron and copper with Na_2CO_3 is that the ferric iron and copper interfere by giving a more or less indefinite end-point which does not represent the true acidity due to free sulphuric acid. This new method gives a sharp end-point in titrating which corresponds to the true free sulphuric acid present. The presence of aluminium salts in amounts usually found in waters, leach liquors, etc., does not interfere, especially in the presence of ferrous iron.

The method depends on the preliminary reduction of ferric to ferrous iron, and of copper to cuprous iodide, by the addition of potassium iodide, and the subsequent change of the free iodine formed to sodium iodide by the addition of the requisite amount of sodium thiosulphate, after which the ordinary titration with Na_2CO_3 is made.

The equations for the above are as follows:

$$Fe_2(SO_4)_3 + 2KI = K_2SO_4 + 2FeSO_4 + 2I$$
$$CuSO_4 + 2KI = CuI + K_2SO_4 + I$$
$$2I + 2Na_2S_2O_3 = 2NaI + Na_2S_4O_6$$

There is needed for carrying out the method:

1. Potassium iodide C.P. (solution or crystals).

2. Solution of sodium thiosulphate, about 10 per cent or any convenient strength, which need not be standardized.

3. Standard sodium carbonate solution. Strength depends on the percentage of acid in the solution to be titrated, and may be anywhere from $N/5$ to N.

4. Methyl orange.

The following is a description of the details of the method.

A definite volume of the solution to be titrated is measured out. This volume will vary widely with different conditions, being dependent on the acidity of the solution and the quantity of salts present, and may therefore be anywhere from 5 to 500 cc.

Dilute to 250 cc., if the solution has not already this volume, and add an excess of potassium iodide. When copper is present there will of course be a precipitation of cuprous iodide and formation of free iodine.

Add sodium thiosulphate in amount sufficient nearly but not quite to neutralize the free iodine present. Then either filter off cuprous iodide and wash three or four times with cold water or dilute to a definite volume, settle and take an aliquot part for determination.

To the filtrate or aliquot part add a slight excess of sodium thiosulphate as measured by the disappearance of the yellow color due to free iodine. When Cu is not present no filtration is necessary after adding KI, and a slight excess of sodium thiosulphate is then added directly.

The solution will now be colorless or practically so, and after addition of methyl orange may be titrated as usual with standard sodium carbonate solution.

The accuracy of the method is shown by the following experiments:

Ten grams of ferrous ammonium sulphate were dissolved in water, and the ferrous iron oxidized to ferric by the addition of just sufficient potassium permanganate in the presence of a known excess of sulphuric acid. The excess acid was then determined by the above method.

Excess acid actually present = 1.930 gm.
Excess acid actually found = 1.918 gm.

It would have been very difficult to have correctly determined the excess acid in the above solution by the ordinary Na_2CO_3 titration, due to the formation of basic ferric sulphate.

For testing the method on leach liquors a solution was made up carrying ferrous and ferric iron and copper in the amounts usually present in such liquors. The amount of free sulphuric acid present was 0.710 lb. per 1000 gal. The amount found by using the above method was 0.706 lb. per 1000 gal., and by the ordinary Na_2CO_3 method 0.915 lb.

In another test 0.91 lb. per 1000 gal. was actually present, and 0.90 lb. per 1000 gal. was found by the above method. The ordinary Na_2CO_3 titration gave 1.14 lb. per 1000 gal. The new method is accordingly more accurate than the ordinary titration with sodium carbonate.

Another test was made by the new method on a solution containing about 5 per cent each of manganous sulphate, ferrous iron, ferric iron, aluminium sulphate and copper sulphate. The amount of free sulphuric acid actually present by addition to this solution was 3.93 per cent. There was found by the new method 3.97 per cent. This solution would have been very difficult to titrate by the usual sodium carbonate method.

Another test was made to determine the effect of aluminium sulphate. It was found that aluminium sulphate did not appreciably interfere provided considerable ferrous iron was present, as the following one of several tests will show. A solution containing by actual addition 1.29 per cent H_2SO_4 and 0.5 per cent $Al_2(SO_4)_3$ was made. The acid was then determined in 300 cc. of this solution with N Na_2CO_3 and methyl orange. It was found to be 1.45 per cent H_2SO_4, an increase of 0.16 per cent due to the hydrolysis of aluminium sulphate. Another portion of 300 cc. to which 1.3 per cent of ferrous sulphate had been added was now titrated and 1.29 per cent H_2SO_4 was found, the correct amount. This may be explained as follows. At the end-point, the free acid having been neutralized, the ferrous iron begins to oxidize and precipitate, hiding the slightly reddish color of the hydrolyzed aluminium salts. Other sulphates were not found to have this effect.

From the above it seems advisable when titrating solutions containing alumina and little or no iron to add ferrous sulphate before titrating.

The acidity due to the hydrolysis of the aluminium sulphate present can be determined also and a correction factor applied to give the true free acid if necessary.

Chlorides and nitrates have not been found to interfere.

New York, N. Y.

Synopsis of Recent Metallurgical and Chemical Literature

Palmerton Zinc Refractories.—A paper describing the manufacture of spelter vessels, condensers and fire-brick at the Palmerton pottery was presented at the St. Louis meeting of the A. I. M. E. by C. P. FISKE of the New Jersey Zinc Co., Palmerton Works. The bond clay is furnished from St. Louis by the Grand View Fire Clay Co. Several kinds of grog have been used, but calcined flint from the Clearfield district of Pennsylvania has given the best results. Pulverized petroleum coke is also a constituent. The Palmerton pottery is a large and well equipped plant, and can turn out large quantities of retorts, muffles and condensers. The author gives a complete description of their manufacture. The fire-brick made are used principally in the spelter furnace laboratory. As to the qualities desired, the author gives some pertinent points. Theoretically, he says, the perfect vessel should have a maximum heat conductivity, refractoriness, mechanical strength and toughness, and a minimum (or no) porosity and coefficient of expansion. At the same time it should be sufficiently strong when dried to allow handling without undue breakage, and should be chemically inert to the various slags which the gangue in the different types of zinc ores produce. Materials which possess all these desirable qualities are, unfortunately, still to be discovered.

"There are many beds of clay in this country whose refractoriness is amply high. The author has examined and tested many such clays which have exceeded the St. Louis clay in refractoriness, usually to find their shrinkage too high or their toughness too low, or both. Although the combination of St. Louis clay and calcined flint gave the best results of any yet tried, there is still much to be desired. The porosity of this mix, when burned, averages about 6.5 per cent. This figure is found by determining the amount of water the mass will take up in 12 to 15 hr., and where water will penetrate in this time zinc vapors and slag will penetrate during service. This is obviously detrimental to vessel life and spelter practice.

"The purpose of calcined grog in the mix is mainly to lessen the shrinkage of the mass as a whole, by introducing a material which has a much lower shrinkage than that of the bond clay. This in itself produces an undesirable effect, for the bond clay still performs its normal shrinkage during burning, and as it must shrink around the grog particles having a much lower shrinkage, minute cracks are opened up which account largely for the porosity found. A one-material vessel, then, should be more satisfactory, or if cost considerations made two or more materials desirable, they should all have the same shrinkage. As a matter of fact, this latter condition is hardly obtainable, as the drying of the bond clay produces shrinkage which in all probability is partially responsible for this porosity.

"We have at times made vessels containing refractories manufactured under various trade names, but so far without sufficient success to warrant the additional cost of the materials.

"One feature that is probably largely responsible for a certain slowness in developing improvements in vessel manufacture is the difficulty in obtaining conclusive tests. A considerable period of time must necessarily elapse between the first steps in the production of an experimental batch and its final trial in the furnaces, and there are so many factors that may influence the results that it is often difficult to decide just what has been accomplished. Operating difficulties may affect the period of rotting and drying, labor conditions at the spelter furnaces may change, ores may change more or less in their character, and so on almost without limit, as those who have tried probably know. Furthermore, such experiments must be handled with caution, for ill-advised innovations are likely to prove very costly.

"The time required for the manufacture of spelter vessels is a further handicap to the pottery man in determining sources of trouble under ordinary operating conditions. A batch of muffles may at times fail after an unusually short life, or may exhibit certain unusual features which are undesirable, but a search for the cause is usually fruitless. A few months ago some of our muffles showed a peculiar blistering on the outside after firing in the kilns, and there were as many opinions given regarding the cause as there were people qualified to express an opinion. A careful search was made to obtain some clue as to the cause, but without avail, and in a short time the trouble disappeared, leaving us as much in the dark as ever.

"If the perfect material is discovered, pottery men will not be slow in making use of it. In the meantime efforts must be directed toward a judicious selection of the materials obtainable, balancing their good qualities against those which would be detrimental to retort service, together with improvements in their combination and treatment."

Japanese Chemical Notes.—The November, 1917, issue of the *Chemical Technology* gives some data on recent developments in Japan. There are now almost 50 companies making dyestuffs and intermediates, and there is developing considerable competition in some lines. Fuming sulphuric acid is being made on a greatly increased scale. Formic, citric, and oxalic acids are made in considerable quantity, and tartaric acid is also being made. The necessity of making chemical machinery and apparatus is being realized, and has been taken up by one concern. Successful experiments have been made in the production of glycerine from fish waste. The Chemical exhibition was a great success, and was visited by the Emperor, Empress, and others of the nobility who are encouraging the industry.

Leather Conservation.—At the third regular meeting of the New York Section of the American Chemical Society on Dec. 7, Dr. ALLEN ROGERS of Pratt Institute, Brooklyn, discussed the subject of leather conservation. His remarks were as follows:

During the past ten years there has been a slow but constant falling off in hides and skins, which has resulted in a gradual decrease in the production of leather. This shortage in raw stock, with the increased demand for leather products, has thus caused a rise in price of all classes of leather. This country has depended very largely upon European markets for its hides and skins, consequently with this source cut off, due to embargo and non-production, the prices have taken extraordinary bounds. To add to the seriousness of the situation, we find ourselves confronted with a shortage in domestic beef animals, and not having an adequate merchant marine, we are unable to reach the South American markets where large quantities of hides and skins are available.

This condition of affairs is deplorable, especially as the United States leads the world in the production of leather. What cannot be cured, however, must be endured. Although conditions in the leather trade are not so serious as they were a year or so ago, we must use every effort to conserve our resources and patiently await the day when a more efficient marine service will bring the markets of the world to our doors.

As the price of any commodity rises, substitutes are bound to appear. This has been true in the case in hand. Not only have leather substitutes been brought forward, but sources of raw material, formerly waste products, have come to the attention of the tanners, and are being worked up into merchantable leather. Processes also are now being employed which aim to produce a leather having a greater wearing quality than in previous years. Some of the processes are

not new, but at the time they were proposed did not meet with favor by the trade. The reason for the lack of interest was due to the fact that the supply of hides was more plentiful than to-day and tanners did not care to change the process to conform to the new method.

In 1911, the speaker, working in conjunction with another member of this Section, developed a method for producing an indestructible sole leather. This leather was tested out on twenty mail carriers and twenty policemen in New York, using it on the right foot with the best oak sole on the left foot. Two oak soles went through and in most cases they were on the third before the new leather wore out. Shoe manufacturers and tanners did not seem interested at that time, but within the past two years several concerns have started to make the leather and it is now being advertised quite extensively.

The skins of fish have been tanned for many years, but only for fancy articles. To-day, however, shark skins, porpoise, and even gray fish and eel skins, are being converted into very serviceable leather. The shark skins have a very hard grain, but the flesh side lends itself to a finish which bids fair to make it a close competitive of box calf or oil grain. Shark skin leather is very tough and serviceable, which makes it well adapted for children's shoes, especially for boys' knockabouts. Gray fish and eel skins are thin, but can be used for fancy leather and small articles.

For many years the waste shavings and trimmings were burnt under the boiler. To-day, however, they are saved by mixing with pulp and put into leather board for insole work.

A recent invention proposes to work up small trimmings from light leather into a thread or yarn, and then use this yarn in weaving leather fabric. Such fabrics may be used for furniture, automobile leather, rugs, and fancy articles.

The heads or pates of hides formerly went into glue stock; to-day, however, these are being tanned and can be bought in the "Five and Ten" as half-soles and heels at ten cents a pair.

In the production of automobile leather the hide is cut up into sections or splits. As a hide can have only one grain side, the other cuts or splits are treated with a dope finish consisting of gun cotton and castor oil, to which a pigment is added. These splits are then embossed and given the appearance of a full grain.

The manufacture of imitation leather is an American idea and has developed into an enormous industry in recent years. This product consists of a fabric to which is applied a dope finish, the same as on splits. The fabric is then embossed and when used on upholstery is difficult to tell from real leather.

A new process has just been invented for making imitation leather, in which cotton batting takes the place of the fabric. This cotton is worked into shape on a felting machine, and then with a suitable binder is pressed into sheets. These sheets are then given a dope finish and embossed. This process is of special interest as the cost of the finished product is less than the cost of the fabric used in the older process. The strength also is far greater than leather or the other imitation leather.

For a number of years we have known and used rubber soles. Recently, however, several sole-leather substitutes have been placed on the market under various trade names. These sole-leather substitutes depend upon rubber for the binding material, but differ from the rubber sole in that they contain loading material and fibrous matter. Although they do not wear as well as high-grade leather, they do have many points of value which should warrant consideration. Coming as they do when leather is short, they have served to tide us over a very serious situation and will continue to serve as a very timely and satisfactory adjunct to our sole-leather supply.

Recent Metallurgical and Chemical Patents

Fractionating Hydrocarbons.—LEON E. HIRT of Los Angeles, Cal., patents an electric arc apparatus for fractionating hydrocarbon oils. In a copending application Serial No. 41,109, filed July 21, 1915, he has described and claimed a method and apparatus for this same general purpose, in which the oil to be fractionated is subjected to the action of an electric arc within a closed furnace or retort, in which a controllable pressure may be maintained. Hydrogen in some form or other suitable agent is present in the retort, the reaction between the hydrogen and the oil under the heat of the arc being present. The oil vapors thereby produced are conducted away and condensed. The present invention adds some further features to this general method. Referring to Fig. 1, the fractionation takes place in

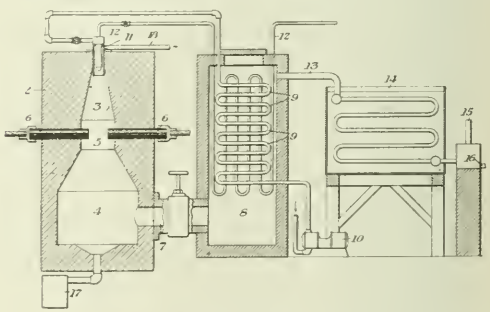


FIG. 1—DIAGRAM OF FRACTIONATING APPARATUS

the furnace or retort chambers designated 3, 4 and 5. Positive pressure of any desired degree can be created within said chamber by regulating the discharge of the vapors to the offtake 7, so as to hold them back within said chamber. In the form of apparatus shown, the ingoing oil is preheated in the chamber 8 to a high degree, since the temperature of the outgoing vapors will be high, depending upon the rate at which oil either atomized or as a vapor is fed. The outgoing temperature can thus be held between 600 and 1500 deg. Fahr, as may be desired. The oil will therefore be discharged into the furnace chamber largely in the form of a vapor and any unvaporized oil will be atomized by the action of the superheated steam passing through the nozzle.

The pump 10 will maintain the oil pressure to the desired intensity, and as the oil and steam pass the arc, the oil is partly broken up and fractionated. The steam introduced with the oil becomes more or less dissociated, the nascent H_2 so formed entering into the reaction with the oils, and by causing the requisite pressure in the furnace chamber, any desired thermochemical compound of the oils can be formed. The O_2 liberated combines with carbon to form CO gas. This is preferable to carbon in the free state, since the latter clogs up the furnace and discolors the condensed fractions. Free chlorine gas may also be introduced with the oil, or oil and steam, to unite with the carbon and form carbon tetrachloride. The latter can be recovered and used as a cleaning compound. Bromine gas may also be added either with or without steam. The halogen gas may be inserted through a pipe, such as indicated at 18. (1,250,879, Dec. 18, 1917.)

Production of Sodium Hydroxide.—CHARLES S. BRADLEY of New York City patents a process for the production of sodium hydroxides and allied products. The process is applicable as an adjunct to the ammonia-soda process. Ammonium chloride and barium carbonate are heated together to form ammonia, carbon dioxide, water and barium chloride. The ammonia, carbon dioxide and water are subjected to a higher temperature and pressure to form ammonium carbonate. This is then subjected to the action of sodium chloride to obtain sodium bicarbonate, regenerating the ammonium chloride. The bicarbonate is reduced to normal carbonate and causticized first with lime, filtered, then causticized with barium hydrate, regenerating barium carbonate for the first reaction with ammonium chloride. (1,249,314, Dec. 11, 1917.)

Lactic Acid.—SIGMOND SAXE of New York City patents a process for the manufacture of lactic acid from vegetable ivory, which is a very hard, ivory-like material used for making buttons and like purposes. Most of it comes from certain tropical American palms (*Phytelephas, sp.*). Waste material from button making and other manufacture can be obtained and used in the process. This is ground to 20 or 30 mesh and hydrolyzed by being boiled with 2 parts of 3 per cent sulphuric acid for six hours and cooled. It is then treated with calcium carbonate and filter pressed, and the liquid is then ready for fermentation. This is done with a lactic organism, capable of producing lactic acid. The fermentation may be conducted in the presence of a base adapted to form lactates, or the fermented mixture may be broken up with sulphuric acid equivalent to the calcium present. (1,249,511, Dec. 11, 1917.)

Potash from Cement Dust.—A process for increasing the solubility of potash in cement-kiln dust is patented by EVALD ANDERSON of Los Angeles (assigned to International Precipitation Co. of Los Angeles, Cal.). Under certain conditions, for example, when coal is used as fuel, causing presence of siliceous matter in the kiln gases, some of the volatilized potash combines with this siliceous matter, forming a difficultly soluble compound. The result is that with potash in this form present in the collected dust, this dust is not rated according to its full potash content as a fertilizer and the recovery of the potash in concentrated form by leaching and evaporation is impracticable, or uneconomical. The main object of the present process is to convert any such comparatively insoluble material in the cement-kiln dust to a comparatively soluble form. This result is effected according to the present invention by subjecting the dust, containing the potash material partly in insoluble form, to the action of steam, preferably at a pressure in excess of atmospheric pressure.

The process is described as follows:

The cement-kiln dust is placed in a suitable container, steam is admitted and the potash containing material is subjected to the action of steam for sufficient time to convert most or all of the potash to water soluble form. In the case of a cement-kiln dust containing six per cent of potash in water soluble form and four per cent in water insoluble form, it was found that an exposure of the same steam at atmospheric pressure (100 deg. C.) is sufficient to convert all but one per cent of the potash to water soluble form. The same effect may be obtained in one hour by the exposure of the cement-kiln dust to steam at two hundred pounds pressure, the rapidity of the action increasing with the pressure and temperature of the steam. After treatment with the steam, the dust may be easily dried, since it absorbs a small percentage of moisture and it may then be used directly as a fertilizer, or it may, if desired, be leached by ordinary means for the purpose of obtaining the potash in a concentrated condition. (1,249,708, Dec. 11, 1917.)

Outlet for Acid Concentrators.—An outlet for acid receptacles is patented by JOEL J. DYE and WM. A. LUCAS of Newark, N. J., and assigned to the Butterworth-Judson Corporation of New York. The patentees state that most acid concentrators have outlets consisting of ordinary pipes with flanges, which are bolted to the wall of the concentrator with interposed gaskets. This method allows hot acid to run over the gaskets and the joints soon leak. The present outlet is designed to do away with this disadvantage. A cross-section of the outlet attached to a concentrator is shown in Fig. 2. The normal acid level is shown at the left.

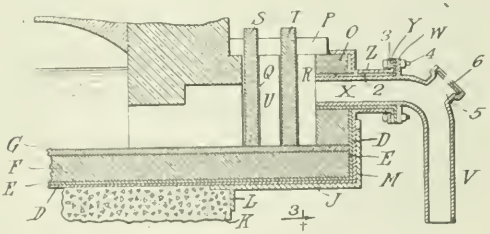


FIG. 2—VERTICAL SECTION OF OUTLET

The tank is constructed of a lead trough *D*, on which is an insulating or packing layer *E* and a course of brickwork *F*, finished with tiling *G*. This floor structure is extended as shown to carry the gates *S* and *T* and the outlet box, which consists of a block *O* of brickwork or other refractory material. A removable cover *P* rests on this block. This serves to prevent the escape of gas. The holes in the cover through which the gates *S* and *T* pass are sealed with sand or other packing material. The outlet pipe *V* is made of acid-proof iron with a flange *W*, located some distance beyond the inlet end of the pipe *X*, which extends into the wall as shown. The flange *W* is bolted to a flange *Y* on the end of a

tubular extension *Z* of the lead casing *D*. There is a seal of the liquid acid between the flame or hot air within the concentrator and the pipe and joints outside, and there is much less expansion of the parts of the joints by heat than where the pipe extends into the concentrator. The temperature of the air within the concentrator may, for example, be about 2000 or 2500 deg. Fahr. while the temperature of the acid is only about 700 deg. (1,249,728, Dec. 11, 1917.)

Wood Distillation.—Apparatus for wood distillation is patented by HARRY O. CHUTE of New York City, and assigned to K. P. McElroy of Washington, D. C. Wood or other vegetable material is destructively distilled in retorts under constant pressure, said pressure being controlled independently of the amount of incondensable gaseous products formed, the gases from the distillation are passed through a temperature-controlled channel to regulate its temperature, and then systematically washed and purified by a countercurrent of tarry or oily bodies, then freed of acetic acid by neutralization with a body of alkaline material maintained at a comparatively high temperature to form an acetate solution and thereafter treated to regain wood spirit. The wood spirit is subsequently purified. The apparatus comprises a retort, means for withdrawing effluent vapors and controlling the pressure, a temperature-regulating device receiving the effluent gases, means for distilling tar, means for systematically scrubbing the effluent gases with the distillate obtained, means for recovering the acetic acid from the purified gases in the form of a concentrated acetate solution, means for thereafter recovering wood spirit, means for purifying said wood spirit, and means for withdrawing incondensable gases, connected to the pressure controlling means. (1,250,282, Dec. 18, 1917.)

Fused Ferric Sulphate.—A process of producing fused ferric sulphate is patented by HERMAN B. KIPPER of Muskegon, Michigan. The raw materials used are sesqui-oxide of iron (iron ore) and niter-cake. The substances are mixed in theoretical proportions and are fused together in any suitable apparatus, at a temperature of 300 to 400 deg. C. If the process is carried out in a rotating drum or cylinder, producer gas is introduced and burned to furnish the heat. The following reaction takes place: $Fe_2O_3 + 6NaHSO_4 = Fe_2(SO_4)_3 + 3Na_2SO_4 + 3H_2O$. The ferric sulphate produced may be mixed with sodium chloride and made into ferric chloride. (1,250,471, Dec. 18, 1917.)

Chlorine Derivatives of Toluol.—The use of ultra-violet light in manufacturing chlorine derivatives of toluol is patented by HARRY D. GIBBS of San Francisco, Cal., and GEORGE A. GEIGER of Washington, D. C. The patent is dedicated to the public. They have found that when the toluol, converted into the gaseous state, is mixed with chlorine gas in definite proportions in the presence of ultra-violet rays, the desired products are produced in greatly increased yields over former processes, and without the production of unfavorable and interfering by-products. They recommend working without a catalyst. The process is especially applicable to the production of benzylchloride, benzolchloride and benzotrichloride. (1,246,739, Nov. 13, 1917.)

Chlorine Substitution Products.—A process for the production of chlorine derivatives of paraffin hydrocarbons is patented by CHARLES BLANC of Akron, Ohio, and assigned to the Goodyear Tire & Rubber Company of Akron. A general description is as follows: Directly into a mass of the employed paraffin hydrocarbon, contained in some suitable reaction chamber, is conducted a stream of chlorine in some measure regulated to conform with the quantity of the hydrocarbon; to facilitate the reaction, particularly in the chlorination of the higher paraffin hydrocarbons, it is advisable to add to the hydrocarbons some halogen carrier. It is essential to this process that the reaction chamber be provided with some means for effectively cooling its contents, and simultaneously exposing said contents to the daylight, or sunlight, or any chemically active artificial light. The contents of the reaction chamber are removed either continuously or intermittently, and any unchanged paraffin hydrocarbon or any undesirable low-chlorinated derivatives of the employed paraffin hydrocarbon, separated from the desired chlorine derivative of the paraffin hydrocarbon by distilling, the unchanged paraffin hydrocarbon or undesirable lower-chlorinated derivatives of the paraffin hydrocarbon being returned to the reaction chamber where they are again submitted to the action of chlorine. The chlorinated paraffin hydrocarbon is removed from the still, washed with some aqueous alkaline solution, separated from the washing solution, and finally, if desired, dried and distilled. (1,248,065, Nov. 27, 1917.)

Potash From Feldspar.—A process for treating potassium-bearing silicate rocks for the recovery of potash is patented by JOHN S. BECKETT of Cranford, N. J., and one-half assigned to P. R. Moses of New York. The process as applied to orthoclase feldspar is as follows:

Orthoclase feldspar is furnaced with coke, limestone and calcium chloride in a copper blast furnace. The calcium chloride is used in sufficient amount to serve as the fluxing agent and to supply the necessary chlorine for forming potassium chloride. The amount of limestone can be varied within rather wide limits, but will in practice be used in such amounts as may be necessary or desirable for giving a melt of low fusion point or for furnishing a melt or sinter of a nature adapted for use for cement or for other purposes. The furnace product can also be thus made use of as a valuable by-product where it is desired to do so. During the furnace operation, the feldspar is decomposed and combines with the limestone and calcium chloride to form a complex silicate, while the chlorine of the calcium chloride combines with the potassium content of the feldspar to form potassium chloride, which escapes with the furnace gases. These highly heated furnace gases are then passed through a waste heat boiler and their heat energy thus recovered in the form of power. The waste gases are then passed through cyclone dust separators where considerable amounts of the potassium chloride are recovered in powder form; after which the waste gases pass to a scrubber in which the remaining potassium chloride is dissolved. The solution thus obtained can be concentrated to crystallization of the potassium chloride, which may then be separated centrifugally or otherwise or the solution can be used directly for the conversion of the potassium chloride into other potassium compounds. The residual melt is drawn off from the furnace to any suitable place of storage or use. When its composition is such that it

is available for use as cement material, it may be granulated by the action of water according to familiar methods. (1,247,619, Nov. 27, 1917.)

Aluminium Alloy.—An aluminium alloy for casting purposes is patented by WILLIAM A. MCADAMS of Bay Shore, N. Y. The ingredients are combined in the proportions of 100 parts by weight of aluminium, seventeen parts by weight of copper, five parts by weight of zinc, one and one-half parts by weight of antimony, and one part by weight of silver. In making the alloy, the antimony is melted in about one quarter of the aluminium at a high heat. The copper is then added and then the silver is added. The heat of the mass is then lowered and the balance of the aluminium is added. The mass is agitated thoroughly and the temperature still further lowered to a dull red and then the zinc is added. The mass is still thoroughly agitated and the scum removed, and the mass may then be cast into ingots. (1,247,977, Nov. 27, 1917.)

Developments in Filtration

AT A MEETING of the New York Section of the Society of Chemical Industry, Oct. 19, 1917, Mr. WALTER L. JORDAN of the Celite Products Company of New York described some very interesting problems in filtration, with particular reference to the use of Filter-Cel as a filter aid.

He divided filtration problems into three classes as follows:

1. Those in which the suspended solids are rigid and either crystalline or amorphous.

2. Those in which the suspended solids are non-rigid bodies, *i.e.*, those approaching the colloidal, although the individual particles may be far greater in size than those properly classed as such.

3. Suspensions containing mixtures of the above classes.

Problems of the first class are the easiest to handle, as it is merely necessary to choose a proper filtering medium, either cloth or screen.

In a few instances precipitates of the second class can be converted into the crystalloidal state either by proper regulation of the precipitation or by subsequent treatment. This should be done wherever possible and thus convert the problem into one under the first class.

Those non-rigid suspended solids which do not lend themselves to crystallization and which have many of the properties and characteristics of colloids (although they may be much larger in size) constitute the most difficult problems in filtration. When one contemplates the difficulties the chemical engineer has to contend with in handling these problems on the large scale, it is easy to understand the aversion to making such separations by filtration and it accounts for the endless attempts that have been made to solve such problems by other means.

Often a problem is rendered more complex by the viscosity of the liquid as in the case of concentrated syrups. In the past gravity filtration has been depended on in coping with this type of problem.

Problems in the third class vary from those in which the rigid particles predominate to those in which practically all the suspended solids are non-rigid.

An example of the third class of problem in which rigid particles predominate is the calcium carbonate precipitate obtained by the carbonation of beet sugar diffusion juice. The precipitated lime carries down albuminous and pectinous bodies through the coagulating effect of liming, heating and carbonating, probably also by adsorption. This precipitate filters readily providing precautions have been taken to bring the calcium carbonate down in a crystalline condition. However, juices from decayed beets offer grave difficulties, because the juices are much higher in organic impurities and especially those of a gelatinous nature, and the normal quantities of lime are not sufficient to render this cake filtrable. Several years ago over 100,000 tons of sugar beets were lost in one State as a result of this condition. The author stated that had supplies of Filter-Cel been available, it would have been possible to have worked these beets up and recovered the sugar.

These two instances in beet sugar carbonation work illustrate the two possible extremes under this class of problem. First the normal beet juice, limed and carbonated, yields a suspension of solids that is readily filtered. In the case of juice from decayed beets the larger percentage of non-rigid solids may make filtration impossible unless much larger quantities of lime or some other filter aid can be incorporated in the cake. The factories burn their own lime and are therefore limited to their normal production of it.

It is always an advantage to coagulate the non-rigid solids as thoroughly as possible. If the impurities are largely albuminous, heat will compact the particles and reduce the volume that they will occupy between the rigid particles present, and the continuity of the pores of the cake will be more nearly maintained. If the coagulation is carried out in the presence of the rigid bodies, the non-rigid will become firmly attached and prevented from being forced through the cake toward the retaining medium.

Some of the diverse problems that have been solved by the application of Filter-Cel as an aid in filtration are as follows:

Vegetable Oils. One of the most interesting applications is in the filtration of linseed oil. This oil is ordinarily filtered warm just as it comes from the hydraulic press. The warm filtered oil on cooling and standing deposits some of the solid fats. By cooling before filtration this after-deposition can be prevented. The addition of about 0.2 per cent of Filter-Cel makes it possible to filter the raw oil at temperatures of 35-40 deg. Fahr. It is probable that a similar procedure would be advantageous in the case of cottonseed and peanut oils, where it is desirable to have an oil of the utmost brilliancy.

Varnishes. Varnishes can be clarified perfectly by filtration in a pressure filter. Usually a thin film of Filter-Cel is first deposited on the cloths from a suspension in clear varnish. The initial film protects the cloths. This is then followed by the cloudy varnish having an additional admixture of ½ to 1 per cent of Filter-Cel.

Lubricating Oils. Used automobile and gas engine lubricating oils contain carbon in a very finely divided state. This carbon has been removed by a Filter-Cel filtration followed by a distillation to remove water, gasoline, etc. It is claimed the revivified oil is superior to the original.

A recent application of Filter-Cel was in the filtra-

tion of wine in a pressure filter. Formerly it was necessary to clarify by means of coagulents such as gelatine, albumen, etc. The process of pressure filtration shortens the time and gives perfect clarification.

Perhaps the most important change in the process of sugar refining in recent years, the author stated, is the adoption of pressure filters of the leaf type in place of the bag filter. This change in method of filtration is made possible by the elimination of the defecation with lime and phosphoric acid. Instead of this a suitable quantity of Filter-Cel is agitated with the liquor just prior to filtration.

Occasionally problems are encountered in which it is not permissible to mix a foreign substance with the precipitate. In such cases, however, it is possible to remove the filter aid in some later process as in the recovery of paraffin by chilling. After the oil has been purged from the paraffin, the latter can be warmed and separated from the Filter-Cel.

The author believes that the use of filtration aids will develop greatly, especially in connection with the more extended use of metallic cloth and screen. Further development will be through the use of higher pressures, thus giving an increased capacity to filtration apparatus.

Flexible Means of Heating Small Space in Industrial Works

The steel-jacketed electric heater-unit shown in the accompanying illustrations has been put to innumerable uses in all kinds of industrial plants. Besides such applications as in crane cabs, valve, pump and meter-

SHOWING AN APPLICATION OF THE C-H SPACE HEATER UNIT IN A METER HOUSE

houses, there have been scores of miscellaneous applications. The ease of conducting electric current to remote corners makes the use of electric heat simpler than any other. The heater-units shown are of 500 watts capacity, and can be connected up in multiple to any a.c. or d.c. circuit where the voltage is not in excess of 250 volts. Only as many as are actually required need be installed, yet additions can be made easily as adding electric lamps. Just as lamps are placed singly or in groups in locations when light is required, so also are these units mounted singly or in groups in locations where heat is required.

The units are flat like an ordinary meter, the dimensions being 3, 18 in. by 1½ in. by 23¾ in. All parts are enclosed and no porcelain, cement, asbestos or moulded insulation material used. Insulated eyelet holes permit the use of ordinary screws for mounting. Terminal connectors are placed at each end. In mount-

SHOWING CARTON IN WHICH C-H SPACE HEATER UNITS ARE PACKED (10 IN A CARTON)

ing, space is provided between units and between unit and surface on which it is mounted to allow for a good circulation of air. The installation view shows one of these C-H units installed in the gas-valve house in a coke plant. These units are designed and manufactured at the New York works of The Cutler-Hammer Manufacturing Company of Milwaukee.

Floating Agitator for Gas Producers

A NEW development in the gas producer line is being placed on the market by the Chapman Engineering Company of Mt. Vernon, Ohio. Fig. 1 illustrates the construction of this machine. The agitator is in the form of an inverted tee, made of double extra-heavy seamless tubing. It revolves through the surface of the fire-bed at the rate of five revolutions per hour, or more if desired. The cross-arms of the tee are provided with stirring fingers made of high-carbon steel. An inner tube carries cooling water to the end of each finger.

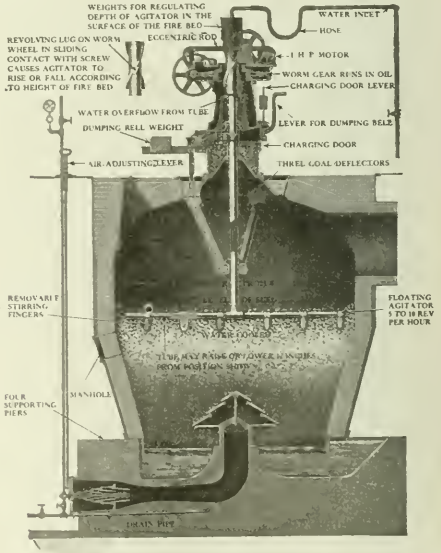

WEIGHTS FOR REGULATING DEPTH OF AGITATOR IN THE SURFACE OF THE FIRE BED
WATER INLET
HOSE
ECCENTRIC ROD
REVOLVING LUG ON WORM WHEEL IN SLIDING CONTACT WITH SCREW CAUSES AGITATOR TO RISE OR FALL ACCORDING TO HEIGHT OF FIRE BED
1 H P MOTOR
WORM GEAR RUNS IN OIL
CHARGING DOOR LEVER
WATER OVERFLOW FROM TUBE
DUMPING BELL WEIGHT
LEVER FOR DUMPING BELL
CHARGING DOOR
AIR ADJUSTING LEVER
THREE GOAL DEFLECTORS
REMOVABLE STIRRING FINGERS
FLOATING AGITATOR 5 TO 10 REV PER HOUR
WATER LEVEL
MANHOLE
FOUR SUPPORTING PIERS
DRAIN PIPE

FIG. 1—INTERIOR VIEW OF GAS PRODUCER WITH FLOATING AGITATOR

The important feature of this agitator is that it automatically accommodates itself to the varying height of the fire-bed. This raising and lowering is accomplished by a special driving-head provided with two large screw-like spiral flanges. These flanges engage in sliding contact with two lugs projecting inwardly from the hub of the driving wheel. Normally the driving wheel and driving-head revolve together, but should the agitator strike an obstruction, or become submerged too deeply in the fire-bed, it automatically "screws up" at once to a point where the forces are again in balance.

If an excessively high fire-bed ever caused the agitator to "float" up to its extreme limit (2 ft.), it would automatically release, thus relieving all strain upon the machinery. The mechanism is driven by a 1 hp. inclosed-type motor.

The agitator is not designed to break up clinkers after they are formed, but to prevent their formation by destroying the blow-holes and hot-spots, which are the primary cause both of clinkers and of poor gas. It is claimed that the frequent stirring of the entire surface of the fire-bed greatly increases the capacity, and improves the quality and uniformity of the gas. Practically all hand-poking is said to be eliminated.

It is stated that the machines can easily be applied to any type of stationary producer already in use. Its makers guarantee that it will increase the capacity 75 per cent, reduce the hand-poking 75 per cent, and maintain a richer and more uniform quality of gas.

The following three analyses represent the average gas made by the agitators in three different steel works. No hand-poking was required, and no objectionable clinkers were made.

	Pittsburgh Gas Coal		Indiana Deep Vein Coal
	Rate per hr lb.		Rate per hr lb.
	1995	1600	1400
CO_2	5.2	5.0	6.6
Ill.	0.1	0.8	.02
O_2	0.1	0.4	0.0
CO	24.1	24.6	19.2
CH_4	2.7	3.5	3.8
H_2	14.0	11.5	13.6
N_2	53.9	54.2	56.6
B. T. U.	143.3	151.0	137.5

These agitators are made in two different forms. First, as a part of a complete producer. Second, separately from the producer proper, to be installed on old style hand-poked uroducers already in use. The agitator is built with or without an automatic coal feeder, as required by local plant conditions.

A New Insulating Material

An insulating material which is said to be fireproof, waterproof, acid proof and electric current proof, composed of chemically treated pulverized waste material which may be molded, stamped or pressed into all special or commercial sizes and shapes, has been developed by Harry A. Dorr and will be made by the Dorrite Insulation Company, 188 Culver Avenue, Jersey City, N. J., after Feb. 1, 1918.

A piece of this insulating material, 3 in. (7.6 cm.) in diameter, ⅛ in. (3.2 mm.) thick, was immersed in water for 70 hours, then subjected to 40,000 volts, and no marks, change in weight or leakage appeared; the same piece was boiled for one hour in cutting oil at 650 deg. Fahr. and stood the same test. A piece 6 in. (15.2 cm.) square and ⅛ in. (3.2 mm.) thick stood a test of 88,000 volts in oil without leakage or breakdown.

Personal

Mr. Robert J. Anderson has resigned his position as chief chemist and metallurgist of the Cleveland Metal Products Co., Cleveland, Ohio, to take effect Feb. 1, 1918.

Mr. C. P. Coleman was elected president of the Worthington Pump & Machinery Corporation at a meeting of the board of directors on Dec. 31.

Mr. A. L. Feild, assistant metallurgist at the Lake Superior station of the U. S. Bureau of Mines, has resigned to enter private employment and is succeeded by P. H. Royster, who has been connected with the iron and steel investigation of the bureau for several years.

Dr. Charles L. Reese, Wilmington, Del., was formally elected presiding officer of the Philadelphia, Pa., section of the American Chemical Society at a recent meeting, to serve in that capacity until December, 1918.

Mr. Forest Rutherford, until recently metallurgist and general superintendent of reduction works for the Copper Queen Consolidated Mining Co. (Phelps-Dodge Corporation) at Douglas, Ariz., is now engaged in consulting metallurgical engineering and has an office at 120 Broadway, New York City.

Dr. Charles E. Vanderkleed, formerly connected with the H. K. Mulford Company, Philadelphia, Pa., has become associated with the Markleed Chemical Company, recently incorporated in New York with a capital of $220,000, and which has acquired the plant of the Waverly Chemical Company at Camden, N. J., now engaging in the manufacture of phenolphthalein, acetyl, salicylic acid, and other synthetics.

Mr. C. H. Vom Baur, well known in the electric steel industry, and formerly with Hamilton & Hansell and other concerns, has opened an office at 30 Church St., New York, where he will engage in consulting work and introduce a furnace of his own design.

Mr. A. P. Watt has opened offices in New York City as metallurgist, where he will specialize on the concentration of ores and the treatment of industrial wastes. His offices are at 52 Vanderbilt Avenue, Room 1903.

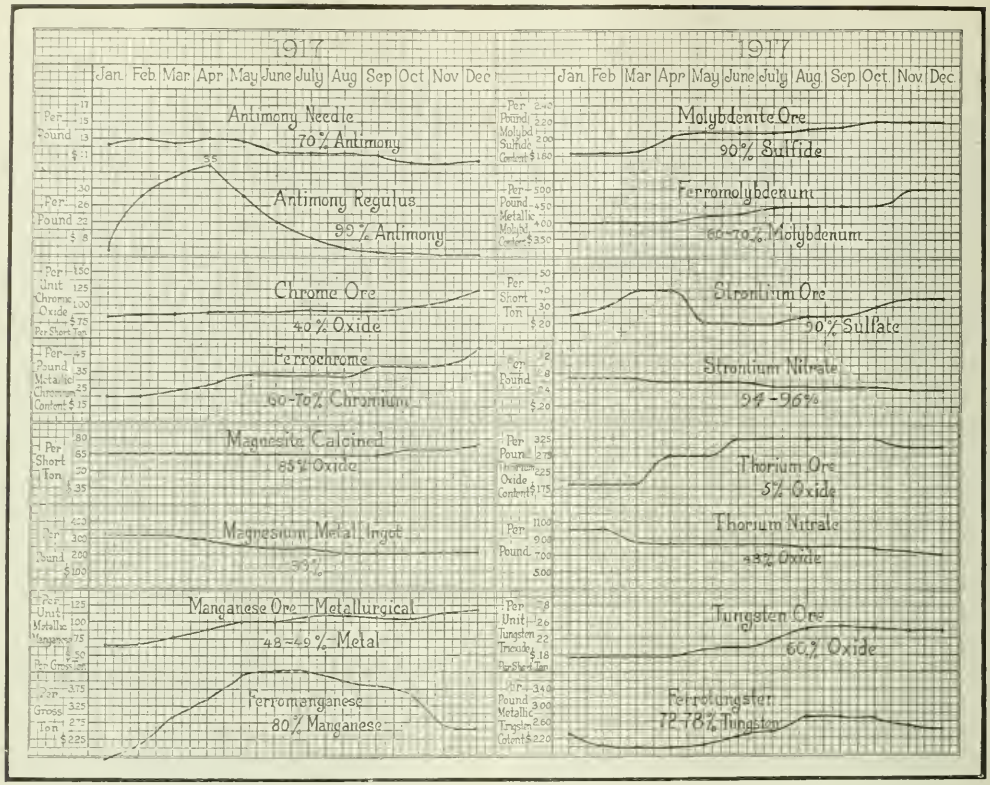
Mr. A. E. Wheeler, consulting engineer for the Union Miniere du Haut Katanga, has recently gone to their head office in London to submit alternative plans for the metallurgical treatment of a large body of oxidized ore occurring on their concession in the Belgian Congo near Elizabethville.

Mr. Bruce C. Yates, assistant superintendent and chief engineer of the Homestake Mining Co., Lead, S. D., has been appointed superintendent to succeed Richard Blackstone, who retired on Jan. 1, 1918. Mr. Yates is a graduate of the University of Nebraska and has been with the Homestake company for the last 20 years.

Obituary

Mr. Silas W. Eccles, vice-president of the American Smelting & Refining Co., passed away at St. Augustine, Fla., on Dec. 31, 1917. Mr. Eccles was also president of the Alaska Steamship Co. and president of the Copper River & Northwestern Railroad. He was born in Washington, Ill., Jan. 3, 1852, and commenced his career in business as a station agent and telegraph operator for the Chicago & Alton Railroad. In 1876 he went to the Denver & Rio Grande Railroad and a year later was appointed general passenger agent of the system.

Prior to becoming connected with the American Smelting & Refining Co. Mr. Eccles was traffic manager of the Oregon Short Line Railroad. In 1900 he became identified with the smelting and refining business, and became a director of the American Smelting & Refining Co. He was also president of the Nevada Northern Railroad and an officer and director of other corporations.



Prices of Some Less Common Products in 1917

The accompanying chart, for which we are indebted to the Foote Mineral Company of Philadelphia, shows the variation in prices in 1917 of several interesting products, including ores, ferroalloys, etc. In addition we include below data on several products also furnished by courtesy of the above company.

Bismuth.—The price remained fairly steady at $3.25 per lb. during the first half of the year. During the last quarter of the present year prices declined still further, due to importations of crude bismuth metal from South America by independents. The present quotations for pure metal range according to quality from $2.65 to $3.00 per pound. The activities of independent South American producers of crude metallic bismuth indicate still further recessions in price for the coming year.

Cerium.—Cerium products remained firm during the year. The two most important products are metallic cerium and cerium oxalate. Ferrocerium was steady at $25.00 per lb. for large contracts. Production is believed to be several thousand pounds per month, and is in the hands of practically only one manufacturer owing to foreign patents.

Palladium.—Owing to the large demand from manufacturers of platinum substitutes the price advanced from $115 in the spring to $125 in the summer and higher figures are now being paid. The bulk of the production is sold far ahead.

Selenium.—Remained firm at $1.20 per lb. during first half of year. During last half an increased demand from the glass trade sent it up to $2.60 to $3.25.

Uranium.—Price remained firm at $50.00 to $60.00 per unit per ton for ore carrying 2 per cent U_3O_8. Black uranium oxide remained firm at $3.25 per lb., 96 per cent U_3O_8.

Vanadium.—Ferrovanadium ranged from $2.75 to $3.00 per lb. of metal contained for 30 to 35 per cent material. During the last quarter this price advanced to as high as $7.50, owing to large Government demands.

Current Market Reports

The Iron and Steel Market

Announcement on behalf of the President, Dec. 28, that iron and steel prices as set would be continued to March 31, has not resulted in any change in the general situation as to activity. The market remains very dull all along the line, a reflection doubtless of general conditions. There is still a large volume of contract business to be carried out, and under present conditions, with prices set, with Government priority being given on a great deal of material, and with the rate of production uncertain, the natural tendency is not to buy for deliveries far ahead. A part of the dullness of the past few weeks is doubtless to be attributed to the year-end adjustments, taking of inventory, making up tax estimates, etc., all particularly complicated this year, and having to be accomplished with reduced office forces, so that the usual tendency of the iron and steel market to be dull at this season is naturally accentuated.

Price Revision Later

The trade, both sellers and buyers, seems to have tacitly assumed that the proviso in the Washington announcement, that contracts made involving delivery after March 31 must carry a clause providing for readjustment of prices against any prices that may be set later by a Government agency, means that probably prices will be re-

duced by March 31 or shortly thereafter. The only question is whether the Washington authorities are looking forward to a voluntary agreement by the iron and steel producers for lower prices, or are depending upon prospects that the Pomerene iron and steel price fixing bill will be enacted. It is understood that the bill is to have precedence over nearly everything else in the two houses.

The contention that the present set prices are necessary by reason of the cost of production has not been particularly successful. The costs of some producers are extremely high, but they represent only a small percentage of the total production, and in many cases high costs are directly traceable to there being contracts for raw materials at higher than the set prices or to irregular operation due to congested traffic conditions. The Federal Trade Commission desires to correct the first drawback to economical production by having Congress give the Executive the authority to cancel such contracts, while the latter difficulty is to be corrected by producing better transportation conditions. That would be a small thing for Government operation of the railroads to accomplish, for the total amount of transportation the iron and steel industry has lacked, between its recent rate of operation and operation at capacity, is only a fraction of 1 per cent of the total freight moving facilities of the country, measured in ton-miles.

Pig Iron Production

For several weeks the blast furnaces tributary to the Connellsville coke region have operated at an average of 80 to 90 per cent of capacity in the case of the merchant stacks and at 70 to 85 per cent in the case of the steel works furnaces. Shipments of Connellsville coke have averaged barely 300,000 net tons a week, against 350,000 tons a week during the first nine or ten months of 1917 and 421,000 tons a week in 1916. The furnaces do not need as much of this coke as in 1916, by reason of many by-product ovens having since been completed. The coke region maintains it could have shipped much more coke if transportation had been available. So far as can be seen, if transportation were provided 75,000 tons more coke per week could be furnished, and that would mean, say, 75,000 tons more pig iron a week. With intermittent operation through frequent banking, and through coke being held in ovens over 72 hours waiting cars and getting overburned, the average coke consumption at many blast furnaces has risen by hundreds of pounds per ton of iron. Now 75,000 tons more pig iron would mean correspondingly more steel and the market might take on quite a different aspect if there were this increased production, for there is no evidence that consumers generally have been greatly incommoded by the reduced deliveries of the past few weeks. The increased output of iron and steel might prove quite formidable, whereas the additional transportation required is inconsequential. The 75,000 tons of coke a week would represent roughly about 10,000,000 ton-miles of freight per week, and last summer at any rate the railroads of the United States were producing more than 8,000,000,000 ton-miles of freight movement per week. Thus one-eighth of 1 per cent more transportation applied to the iron and steel industry would probably produce a very striking alteration in the relation between demand and supply.

Contracts in Force

The finished steel industry is operating largely on old contracts. In bar, shapes and plates the deliveries, apart from those on Government orders, are chiefly against contracts made prior to last May, since which time there has been little buying of these products except for early deliveries, or against Government requirements. In pipe, wire products and sheets the deliveries are more against sales made lately for shorter periods. The interest of the mills at this time is chiefly in converting the present contract obligations into definite orders and shipments. In most cases there is no definite sales policy, the idea being that that is a matter for the future, and the market is really drifting. In a few weeks more, particularly if transportation conditions improve, the future of the steel market, as to prices and demand, should have at least a little light thrown upon it.

War Requirements

There is much confusion of thought as to the war requirements in steel, this being caused by the natural tendency to ascribe nearly all steel consumption to war requirements, as nearly all the consuming industries are more or less helpful in prosecuting the war. This is theoretically a correct viewpoint, but practically it settles nothing, for it is not the production of steel but the use of steel that helps to win the war, and these consuming industries have their limitations, which, of course, are purely physical. Those who use steel as a result of being given Government orders, as munition manufacturers, shipbuilders and the like, are in one category; those who use steel to produce oil, coal, farm implements and the like are in another category. To the former price may be no object. To the latter it is an object.

There are certainly possibilities of steel in many forms becoming decidedly more plentiful and indeed of having occasion to seek its market. Leadership in point of scarcity has for nearly two years been given to plates, yet the market in the past fortnight has disclosed rather free offerings of plates, of certain specifications, by half a dozen or more mills, and when that occurs in plates there is room for much inference as to what may occur in the next few months as to steel products generally.

Non-Ferrous Metal Market

Monday, Jan. 7.—The tin market is dull and prices are considerably lower, in spite of the great scarcity of supplies. Nothing of special interest has happened in the copper and zinc markets. Lead has been advanced by the Trust.

Copper.—The prices remain at 23.50 for producers and 24.67½ for jobbers as fixed by the Government. There is apparently enough copper available for all purposes at present, but considerable concern is felt over the coal and railroad situation. In London standard is quoted at £110 and electrolytic at £125. The demand for copper in munitions making is expected to increase rapidly.

Tin.—The situation is no better and were it not for the fact that there seems to be but little consuming demand a very serious situation would be the result. Two weeks ago Straits tin sold up to 85 cents, but it has now declined to a nominal quotation of 67 cents, following a sensational decline in the London market from £302½ to £269. The London market has recovered, however, and spot Straits is quoted now at £281. Total deliveries in December were 4683 tons, with stocks on hand at the end of December of only about 500 tons. Spot tin of any kind is hard to obtain at present. Future Chinese No. 1 is quoted at 62.00 cents.

Lead.—The trust price of lead was advanced on Jan. 3 to 6.50 cents New York basis. The outside price is 6.75 to 7.00 cents. Following a dull period, a large demand has sprung up from consumers. Government purchases have been settled on the average St. Louis prices, while New York prices were lower.

Spelter.—This market continues dull, with a slightly better demand for Grades A and B for Government work. Grade B is now 10.25 cents. Prime Western is held at 7.75 cents.

Antimony.—The antimony market continues dull, with 14.50 cents quoted.

Tungsten.—Tungsten ore remains at $24.00 for high-grade wolframite and $26.00 for scheelite. It is difficult to move material on account of the railroad congestion.

Molybdenite.—Price remains at $2.25 to $2.30 per lb., with a fair demand.

Quicksilver.—Supplies are scarce and the market has advanced to $130-$135 per flask for California material.

Other Metals

Aluminium, lb.	.36–.38
Bismuth, lb.	3.00–3.50
Cadmium, lb.	1.50
Nickel, electrolytic, lb.	.55
Silver, oz.	.89⅝
Platinum, oz.	105.00
Palladium, oz.	130.00–135.00

Chemical Market

Coal Tar Products.—Conditions in this market have been quiet of late. The requisitioning by the government of several of the important items has tended to a certain extent to restrict operations. The scarcity of material has also contributed toward the conditions obtaining.

Benzol.—Offerings are liberally made, but the buying demand is much below normal. Consumers of large quantities who ordinarily cover for the year on contract are backward about doing so and low prices therefore hold sway.

Phenol.—Governmental requirements are receiving first consideration and offerings are light, with a slight advance in price.

Naphthalene.—Not much interest is displayed by either buyers or sellers at present, spot material is scarce and forward positions are fractionally advanced in price.

Toluol.—The government has seized practically the whole production, and there is none obtainable on the open market. A few drums pass now and then at fancy figures.

Aniline Oil.—A slightly improved demand, together with a scarcity of the necessary acids, has caused a firmer position and a slight advance in price.

Salicylic Acid.—The production of late has been heavy and a few factors in the market were absorbing the output until recently, when their requirements were filled, with the result that prices have declined.

Beta Naphthol.—Was in better demand and spot stocks of the technical grade are in light supply, but prices thus far are unchanged. The sublimed material is in better supply and the demand is light.

Dinitrophenol.—Offerings are liberal with the demand light and prices unchanged.

Para-amidophenol.—A heavy production with a falling off in the demand has caused prices to decline.

Ortho-Toluidine.—The toluol situation has caused a scarcity of this material, and only a few dealers are quoting, with prices slightly higher.

Para Toluidine.—Is in better supply, although there are only a few dealers offering, with prices unchanged.

Anthracene.—Is practically off the market, several inquiries having failed to locate material quantities.

HEAVY CHEMICALS.—The movement in chemicals during the past two weeks has been of a minor character and prices, as is usual toward the close of the year, have shown a tendency to ease off. There is reported to have been more inquiries coming in during the first week of the new year, and this is generally taken as an indication of activity soon to develop.

Caustic Soda.—There has been no real buying for consuming accounts since our last report. The short interest which has developed during the period since Oct. 1 is reporting much difficulty in having bills of lading accepted and these bills are being rejected on the slightest technicality. As a consequence there has been a decided speculative interest shown in certain positions such as December bills of lading for 25-ton cars. Buyers have been willing to pay concessions to cover in exact conformity with contracts to avoid disputes. Spot positions have receded to 6.40 and 6.50. Over the year quotations vary from 6.35 to 6.60, according to seller. The usual probability of nondelivery attaches to the low quotations.

Soda Ash.—Owing to the lack of export licenses, bags have firmed up and are scarce, while barrels are more plentiful and easier. The movement has been entirely speculative, however. December bills of 25-ton cars have been mostly in demand to fill in contracts. These commanded 3.05 to 3.10 as we write, while barrels in contrast were available at 3c. to 3.05c. From the works bags were obtainable at 2.90c. to 3c.; barrels at 3c. to 3.05c.

Acids.—As there is seemingly no sulphuric acid other than the 66-degree concentration and but limited trading in that, there is little that can be stated regarding the market. Sixty-six degree brimstone acid has sold at $75 to $80, drums included, with a few spot offerings from time to time at $43, drums extra. *Oleum* has sold at $65 and $75, and $80 is now asked. *Muriatic acid* as a result of government buying has become so scarce that the 18-degree material is now practically the only test available and sellers are asking 4c. for June-December delivery. *Nitric acid* has not been so active, and 42-degree material is available at 9c. to 10c. *Phosphoric acid* has eased off owing to the lack of demand and the 48/52 per cent is now available at 7c. to 7¼c.

Chlorate of Potash.—Manufacturers established the price of 40c. shortly before the new year covering 1918 business and shortly announced that in some instances this price had been advanced to 42½c. However, the outside market has not responded and sales of December chlorate were closed the first week of the year at 39c. It will be recalled that all during 1917 the outside market was lower than the contract price.

Bichromates.—Spot soda and potash has been somewhat firmer. This is principally due to the railroad situation. For soda the 1918 price is 16½ to 17c., but the contracts contain so many war clauses that the buyer really does not know how much he will pay for the product before he consumes it.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, JAN. 7, 1918

Acetic anhydride	lb.	1.80 — 1.90
Acetone, drums	lb.	Nominal
Acid, acetic, 28 per cent	lb.	.05½— .06
Acetic, 56 per cent	lb.	.11¼— .12
Acetic, glacial, 99½ per cent, carboys	lb.	.34 — .35
Boric, crystals	lb.	.13¼— .14¼
Citric, crystals	lb.	.75 — .78
Hydrochloric, C.P	lb.	Nominal
Hydrochloric, 20 deg	lb.	Nominal
Hydrochloric, conc., 22 deg	lb.	Nominal
Hydrofluoric, 30 per cent, in barrels	lb.	.06¼— .06½
Lactic, 44 per cent	lb.	.15 — .15½
Lactic, 22 per cent	lb.	.05½— .06½
Nitric, 36 deg	lb.	.09 — .10
Nitric, 42 deg	lb.	.09 — .10
Oxalic, crystals	lb.	.45 — .46
Phosphoric, 47 per cent-50 per cent	lb.	.07 — .07½
Picric	lb.	Nominal
Pyrogallic, resublimed	lb.	3.15 — 3.25
Sulphuric, 60 deg	tan	.....
Sulphuric, 66 deg	ton	42.00 — 44.00
Sulphuric, oleum (Fuming), tank cars	ton	70.00 — 80.00
Tannic, U. S. P., bulk	lb.	1.30 — 1.35
Tartaric, crystals	lb.	.78 — .80
Tungstic, per lb. of W	lb.	1.80 — 1.90
Alcohol, sugar cane, 188 proof	gal.	5.05 — 5.25
Alcohol, wood, 95 per cent	gal.	Nominal
Alcohol, denatured, 180 proof	gal.	.78 — .80
Alum, ammonia lump	lb.	.04½— .05
Alum, chrome ammonium	lb.	.18 — .19
Alum, chrome potassium	lb.	.23 — .25
Alum, chrome sodium	lb.	.12½— .13
Alum, potash lump	lb.	Nominal
Aluminium sulphate, technical	lb.	.02½— .02½
Aluminium sulphate, iron free	lb.	.02¾— .03
Ammonia aqua, 26 deg. carboys	lb.	.19½— .20
Ammonium carbonate	lb.	.11 — .12
Ammonium nitrate	lb.	(Fixed price) .14
Ammonium, sulphate domestic	lb.	.07¼— .07½
Amyl acetate	gal.	5.25 — 5.40
Arsenic, white	lb.	.15 — .16
Arsenic, red	lb.	.65 — .70
Barium carbonate, 99 per cent	ton	80.00 — 90.00
Barium carbonate, 97-98 per cent	ton	65.00 — 67.00
Barium chloride	ton	70.00 — 90.00
Barium sulphate (Blanc Fixe, powder)	lb.	.03½— .04
Barium nitrate	lb.	.09½— .11
Barium peroxide, basis 70 per cent	lb.	.32 — .38
Bleaching powder, 35 per cent chlorine	lb.	.02½— .02¾
Borax, crystals, sacks	lb.	.07¼— .08¼
Brimstone, crude	ton	Nominal
Bromine, technical	lb.	.65 — .70
Calcium, acetate, crude		Nominal
Calcium, carbide	lb.	.08½— .11
Calcium chloride, 70-75 per cent, fused, lump	ton	21.00 — 25.00
Calcium peroxide	lb.	1.60 — 1.70
Calcium phosphate	lb.	.30 — .31
Calcium sulphate	lb.	.....
Carbon bisulphide	lb.	.07 — .07½
Carbon tetrachloride, drums	lb.	.14 — .16
Caustic potash, 88-92 per cent	lb.	.82½— .....
Caustic soda, 76 per cent	lb.	.06½— .06¾
Chlorine, liquid	lb.	.15 — .18
Cobalt oxide	lb.	1.40 — 1.50
Copperas	lb.	.01¼— .01½
Copper carbonate	lb.	.45 — .....
Copper cyanide	lb.	.75 — .78
Copper sulphate, 99 per cent, large crystals	lb.	.09 — .09½
Cream of tartar, crystals	lb.	.61 — .63
Epsom salt, bags	lb.	.03¼— .04
Formaldehyde, 40 per cent	lb.	.19½— .20
Glauber's salt	100 lb.	1.00 — 1.10
Glycerine, bulk, C. P.	lb.	.67½— .70
Iodine, resublimed	lb.	4.25 — 4.35
Iron oxide	lb.	.13 — .15
Lead, acetate, white crystals	lb.	.17 — .17½
Lead arsenate (Paste)	lb.	.15 — .18
Lead nitrate	lb.	Nominal
Litharge, American	lb.	.09½— .11½
Lithium carbonate	lb.	1.50 — 2.00
Manganese dioxide, U. S. P.	lb.	.70 — .75
Magnesium carbonate, tech	lb.	.10 — .10½
Nickel salt, single	lb.	Nominal
Nickel salt, double	lb.	Nominal
Phosphorus, red	lb.	1.70 — .....
Phosphorus, yellow	lb.	1.25 — .....
Potassium bichromate	lb.	.45 — .46
Potassium bromide granular	lb.	1.45 — 1.50

Potassium carbonate calcined, 85-90 per cent	lb.	60	—	.65
Potassium chlorate, crystals	lb.	40	—	.42½
Potassium cyanide, 98-99 per cent	lb.	Nominal		
Potassium iodide	lb.	3.75	—	3.80
Potassium muriate 80-85 p.c. basis of 80 p.c.	ton	350.00		
Potassium nitrate	lb.	.30	—	.32
Potassium permanganate (U.S.P.)	lb.	.80	—	.85
Potassium prussiate, red	lb.	2.60	—	2.70
Potassium prussiate, yellow	lb.	1.25	—	1.35
Potassium sulphate, 90-95 p.c. basis 90 p.c.	ton	Nominal		
Rochelle salts	lb.	.39	—	.39½
Salammoniac, gray gran	lb.	.15	—	.16
Salammoniac, white gran	lb.	.16	—	.17
Sal soda	100 lb.	1.25	—	1.30
Salt cake	100 lb.	1.50	—	2.00
Silver cyanide, based on market price of silver	oz.			
Silver nitrate	oz.	.53	—	.55
Soda ash, 58 per cent, light, flat	100 lb.	2.90	—	3.05
Soda ash, 58 per cent, dense, flat	100 lb.	3.50	—	4.00
Sodium acetate	lb.	.16½	—	.17
Sodium benzoate	lb.	.3.75	—	.85
Sodium bicarbonate, domestic	lb.	.02¾	—	.03
Sodium bicarbonate, English				
Sodium bichromate	lb.	.17½	—	.18
Sodium bisulphite, powd	lb.	.06¾	—	.06½
Sodium chlorate	lb.	.20	—	.22
Sodium cyanide	lb.	.42	—	.44
Sodium fluoride, commercial	lb.	.18½	—	..
Sodium hyposulphite	lb.	.02	—	.02¼
Sodium molybdate, per lb. of Mo	lb.	2.50	—	..
Sodium nitrate, 95%	100 lb.	3.60	—	3.70
Sodium nitrite	lb.	.30	—	.35
Sodium peroxide	lb.	.45	—	.48
Sodium phosphate	lb.	.04	—	.04½
Sodium prussiate, yellow	lb.	.36	—	.37
Sodium silicate, liquid. (60 deg.)	100 lb.	4.00	—	4.50
Sodium sulphide, 30 per cent crystals	lb.	.02¾	—	.03
Sodium sulphide, 60 per cent, fused	lb.	.04½	—	.05
Sodium sulphite	lb.	.05	—	.06
Strontium nitrate	lb.	.25	—	.35
Sulphur chloride, drums	lb.	.06	—	.06½
Sulphur dioxide, liquid, in cylinders	lb.	.15	—	.40
Sulphur, flowers, sublimed	100 lb.	4.05	—	4.10
Sulphur, roll	100 lb.	3.70	—	3.85
Sulphur, crude		Nominal		
Tin bichloride, 50 deg	lb.	.23¾	—	.24½
Tin oxide	lb.	.85	—	1.00
Zinc carbonate	lb.	.22	—	.25
Zinc chloride	lb.	.10¾	—	.11
Zinc cyanide	lb.	Nominal		
Zinc dust 350 mesh	lb.	.17	—	.18
Zinc oxide, American process XX	lb.	.11¾	—	.12
Zinc sulphate	lb.	.06	—	.07

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.35	—	.40
Benzol, 90 per cent	gal.		—	..
Toluol, pure water white	gal.	Nominal		
Xylol, pure, water white	gal.	.45	—	.50
Solvent naphtha, water white	gal.	.17	—	.22
Solvent naphtha, crude, heavy	gal.	.13	—	.16
Creosote oil, 25 per cent	gal.	.33	—	.35
Dip oil, 20 per cent	gal.	.29	—	.30
Pitch, various grades	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05	—	1.10
Carbolic acid, crude, 50 per cent	lb.	.60	—	.65
Carbolic acid, crude, 25 per cent	lb.	.35	—	.38
Cresol, U. S. P.	lb.	.18	—	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.10	—	..
Alpha naphthol, distilled	lb.	1.60	—	..
Alpha naphthylamin	lb.	.58	—	.60
Aniline oil, drums extra	lb.	.26	—	.27
Aniline salts	lb.	.32	—	.34
Anthracene, 80 per cent	lb.	.50	—	.65
Benzaldehyde	lb.	4.00	—	4.50
Benzidine, base	lb.	1.75	—	1.85
Benzidine, sulphate	lb.	1.40	—	1.50
Benzoic acid	lb.	4.00	—	..
Benzyl chloride	lb.	1.75	—	1.85
Beta naphthol benzoate	lb.	7.00	—	8.00
Beta naphthol, sublimed	lb.	.85	—	.90
Beta naphthylamin com	lb.	.50	—	2.65
Dichlor benzol	lb.	.12	—	.18
Diethylaniline	lb.	1.00	—	5.00
Dinitro benzol	lb.	.34	—	.50
Dinitrochlorbenzol	lb.	.40	—	.42
Dinitronaphthaline	lb.	.55	—	.60
Dinitrotoluol	lb.	.55	—	.60
Dioitrophenol	lb.	.55	—	.57
Dimethylaniline	lb.	.57	—	.62
Diphenylamine	lb.	.85	—	1.00
H-acid	lb.	2.25	—	2.50
Metaphenylenediamine	lb.	1.85	—	2.00
Monochlorbenzol	lb.	.19	—	.22
Naphthalene, flake	lb.	.09¾	—	.10
Naphthalene, balls	lb.	.10½	—	.10¾
Naphthionic acid, crude	lb.	1.10	—	1.50
Naphthylamin-di-sulfonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.45	—	.56
Nitro toluol	lb.	.50	—	.55
Ortho-amidophenol	lb.	..	—	..
Ortho-toluidine	lb.	1.00	—	1.20
Orth-nitro-toluol	lb.	.75	—	1.00
Para-amidophenol, base	lb.	3.50	—	4.00
Para-amido-phenol, H. Ch	lb.	4.00	—	4.25
Paranitraniline	lb.	1.05	—	1.15
Para-nitro-toluol	lb.	1.50	—	1.60
Paraphenylenediamine	lb.	3.00	—	3.50
Para toluidine	lb.	2.25	—	..
Phthalic acid anhydride	lb.	6.30	—	6.40
Phenol, U. S. P.	lb.	.53½	—	.55
Resorcin, technical	lb.	6.50	—	7.50
Resorcin, pure	lb.	12.00	—	12.50
Salicylic acid	lb.	1.10	—	1.20
Salol	lb.	1.85	—	2.00
Sulphanilic acid	lb.	.32	—	.35
Toludin	lb.	2.50	—	..
Toluidine-mixture	lb.	.75	—	.85

Petroleum Oils

Crude (at the Wells)				
Pennsylvania	bbl.	3.75	—	..
Corning, Ohio	bbl.	2.80	—	..
Somerset, Ky	bbl.	2.55	—	..
Wooster, Ohio	bbl.	2.38	—	..
Indiana	bbl.	1.98	—	..
Illinois	bbl.	2.12	—	..
Oklahoma and Kansas	bbl.	2.00	—	..
Caddo, La., light	bbl.	2.00	—	..
Corsicana, Tex., light	bbl.	2.00	—	..
California	bbl.	.98	—	1.32
Gulf Coast	bbl.	1.00	—	..
Fuel Oil				
New York	gal.	.11	—	..
Pittsburgh	gal.	.07½	—	.10
Oklahoma-Kans	bbl.	1.50	—	2.35
Texas	bbl.	1.50	—	1.75
Los Angeles	bbl	1.52	—	..
San Francisco	bbl.	1.45	—	..
Gasoline (Wholesale)				
New York	gal.	.24	—	..
Boston	gal.	.25	—	..
Pittsburgh	gal.	.26	—	..
Chicago	gal.	.21	—	..
Oklahoma	gal.	.25	—	..
San Francisco	gal.	.20½	—	..

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.18	—	.19
Cylinder, light	gal.	.32	—	.33
Cylinder, dark	gal.	.30	—	.31
Paraffine, high viscosity	gal.	.35	—	.36
Paraffine, .903 sp. gr.	gal.	.27	—	.28
Paraffine, .865 sp. gr.	gal.	.19	—	.20

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f.o.b. Florida	gal.	.44	—	..
Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.50	—	..
Pine oil, destructively distilled	gal.	.43	—	.53
Pine-tar oil, sp. gr. 1.025-1.035	gal.	.30	—	..
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.35	—	..
Pine oil, light, sp. gr. 0.930, tank cars, f.o.b. works	gal.	.37	—	..
Pine oil, heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.26	—	..
Pine tar, thin, sp. gr. 1.060-1.080	gal.	.32	—	..
Turpentine, crude, sp. gr. 0.980-1.000	gal.	.40	—	..
Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990	gal.	.21	—	..
Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08	gal.	.19½	—	..
Wood creosote, ref. f.o.b. Florida	gal.	.31	—	..

Vegetable and Other Oils

China wood oil	lb.	.20	—	.21
Cottonseed oil, crude	gal.	1.31	—	..
Linseed oil, raw, cars	gal.	1.28	—	..
Peanut oil, crude	gal.	1.37	—	..
Rosin oil, first run	gal.	.35	—	..
Rosin oil, fourth run	gal.	.65	—	..
Soya bean oil, Manchuria	lb.	.17¾	—	.18
Turpentine, spirits	gal.	.50	—	.51

Miscellaneous Materials

Barytes, floated, white, foreign	ton	40.00	—	50.00
Barytes, floated, white, domestic	ton	30.00	—	36.00
Beeswax, white, pure	lb.	.56	—	.64
Casein	lb.	.22	—	.30
Chalk, light, precipitated, English	lb.	..	—	..
Feldspar	ton	8.00	—	12.00
Fuller's earth, powdered	100 lb.	1.00	—	1.50
Ozokerite, crude, brown	lb.	.65	—	.75
Ozokerite, American, refined, white	lb.	.75	—	1.00
Red lead, dry, carloads	lb.	.10	—	.11¾
Rosin, 280 lb.	bbl.	7.20	—	..
Soapstone	ton	10.00	—	12.50
Talc, American, white	ton	15.00	—	22.00
White lead, dry	lb.	.09	—	.10

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	Nominal		
Chrome cement, Grecian	net ton	Nominal		
Clay brick 1st quality fireclay	per 1000	50.00	—	55.00
Clay brick, second quality	per 1000	35.00	—	40.00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined	ton	40.00	—	55.00
Magnesite, Grecian, dead burned	net ton	85.00	—	90.00
Magnesia brick, Grecian, 9x4½x2½	net ton	135.00	—	140.00
Silica brick	per 1000	50.00	—	60.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f.o.b. Niagara Falls, N. Y.	ton	160.00	—	..
Ferrochromium, per lb. of Cr	lb.	.40	—	.45
Ferromanganese, domestic	ton	250.00	—	..
Ferromanganese, English	ton	325.00	—	..
Ferromolybdenum, per lb. of Mo	lb.	5.00	—	..
Ferrosilicon, 75 per cent, f.o.b. N. Y	ton	..	—	..
Ferrosilicon, 50 per cent, carloads, del., Pittsburgh	ton	165.00	—	175.00
Ferrosilicon, 50 per cent, contract	ton	100.00	—	175.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	2.35	—	2.45
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.00	—	..
Ferrovanadium, f.o.b. works	lb.	3.50	—	4.50

Ores and Semi-finished Products

Antimony ore, per unit	unit	1.60	—	1.75
Chrome ore, 48 per cent chromium f.o.b. Cal., per unit	ton	..	—	.90
Manganese ore, 48 per cent and over, per unit	ton	..	—	1.20
Manganese ore, chemical	ton	80.00	—	100.00
Molybdenite, per lb. of MoS_2	lb.	2.25	—	2.30
Tungsten, Scheelite, per unit of WO_3	ton	26.00	—	..
Tungsten, Wolframite, per unit of WO_3	ton	24.00	—	26.00
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium Pentoxide, 99%	lb.	..	—	10.50
Pyrites, foreign	unit	.16	—	.18
Pyrites, domestic	unit	.25	—	.30

INDUSTRIAL

Financial, Construction and Manufacturers' News

New Companies

THE ALLIANCE IRON & STEEL CORPORATION, New York. Capital, $75,000. To engage in the manufacture of iron and steel products. Incorporators: H. F. Holly, H. C. Gable and G. D. Zahm, 261 Broadway.

O. H. ANDERSON & COMPANY, New York. Capital, $50,000. To operate a plant for the manufacture of paper and paper specialties. Incorporators: O. H. Anderson, C. C. and E. Mandel, 163 St. Nicholas Avenue.

THE ANIMAL BY-PRODUCTS COMPANY, Miami, Fla. Capital, $30,000. To engage in the manufacture of fertilizer. Incorporators: W. A. Henderson and L. C. Haughey, Miami.

THE GEORGE BANTA PAPER COMPANY, Menasha, Wis. Capital, $30,000. To operate a plant for the manufacture of finished paper. Incorporators: George Banta, Sr.; George Banta, Jr., and R. E. Thickens, Menasha.

THE BEST FOUNDRY COMPANY, Brooklyn, N. Y. Nominal capital, $9,000. To operate a local foundry. Incorporators: J. Danziger, U. S. Adler and L. B. Louis, 35 Nassau Street, New York.

BLACKMAN & FINK, New York. Capital, $25,000. To engage in the manufacture of chemicals and allied products. Incorporators: M. Fink and J. and E. Blackman, 66 East Ninety-ninth Street.

THE CENTRAL IRON & METAL COMPANY, Paterson, N. J. Capital, $25,000. To engage in the production of iron, steel and other metal products. Incorporators: B. and A. and J. Jacobs, and H. Hurwitz. Paterson.

THE CLEVELAND BRASS PRODUCTS COMPANY, Cleveland Heights, Ohio. Capital, $3,000,000. To manufacture and fabricate brass, zinc, copper, etc. Incorporators: C. R. Hamilton, Edward C. Decust, Cleveland Heights; Mark W. Cole and M. S. Pollock, Dover, Del.

THE COMMERCIAL CYLINDER COMPANY, Hackensack, N. J. Capital, $800,000. To manufacture gas, oils, etc. Incorporators: Cornelius Cole, Hackensack; A. R. Oakley, Pearl River, N. Y.; and Paul E. Britsch, Brooklyn, N. Y.

DECK BROTHERS, Buffalo, N. Y. Capital, $35,000. To operate a local foundry and machine shop. Incorporators: A. G. Bartholomew, B. L. Lempenau and A. S. Perrers, Buffalo.

THE DUNLAP PAPER COMPANY, Batavia, N. Y. Capital, $15,000. To engage in the manufacture of paper. Incorporators: M. Clark, S. Dunlap and A. Hawkins, Batavia.

THE EAST DEERING FOUNDRY COMPANY, Portland, Me. Capital, $10,000. To engage in a general foundry business. Incorporators: George R. Thomas, Charles E. Noyes, Joseph G. Noyes and A. F. Thomas, all of Portland.

THE EUREKA ANILINE PRODUCTS CORPORATION, New York. Capital, $10,000. To engage in the manufacture of dyestuffs and allied products. Incorporators: H. Suhr, H. P. Velte and R. Bennett, 503 West 169th St.

THE FABRICATED STEEL PRODUCTS CORPORATION, New York. Capital, $150,000. To engage in the manufacture of steel products. Incorporators: W. E. I. Lambrecht, H. Lindemann and W. Arnold, 322 Tenth Avenue.

THE GLIDDEN COMPANY, Cleveland, Ohio. Capital, $10,000. To manufacture paints, etc. Incorporators: Howard T. Clark, C. C. Owens, Ellis B. Diehm, Paul J. Bickel and Sterling Newell, Cleveland.

GOLDSMITH BROTHERS SMELTING & REFINING COMPANY, Atlanta, Ga. Capital, $10,000. To engage in the smelting and refining of metals. Incorporators: Frank H. Leslie, Atlanta; Lowell A. Lawson and Leon L. Lewis, both of Chicago, Ill.

THE GOOD CHANCE MINING COMPANY, Miami, Okla. Capital, $30 000. To mine for lead and zinc. Incorporators: George Ostrander, Miami; R. W. Eastman and H. H. Sherman, Alva, Okla.

THE GREAT FINDS OIL & REFINING COMPANY, Wilmington, Del. Capital, $50,000. To drill for oil and gas and refine same.

THE GREAT SCOTT MINING COMPANY, Kansas City, Mo. Capital, $25,000. To engage in the mining of lead and zinc. Incorporators: E. A. MacBride, A. B. Munsey and J. J. Johnston, Kansas City.

THE HELLER & MERZ COMPANY, Newark, N. J. Capital, $1,500,000. To engage in the manufacture of chemicals, dyes, etc. Incorporators: A. Foshay, A. G. Thanum and Arthur Williams, all of New York.

THE HOFFMAN-PERRY IRON & STEEL COMPANY, Youngstown, Ohio. Capital, $75,000. To deal in iron and steel products. Incorporators: Louis Hoffman, Frank C. Hoffman, Frank W. Perry, M. J. Sussman and G. F. Hammond, Youngstown.

THE HOME PULP & PAPER MILLS COMPANY, Mobile, Ala. Capital, $100,000. To manufacture paper and paper products. Incorporators: F. B. Armstrong, J. S. Armstrong and M. McGowan, all of Mobile.

THE LAMBERT CHEMICAL COMPANY, St. Louis, Mo. Capital, $20,000. To manufacture chemicals and allied products. Incorporators: W. and A. W. Lambert and A. R. Deacon, St. Louis.

S. B. LEONARDI & COMPANY, New York. Capital, $10,000. To manufacture chemicals and kindred products. Incorporators: B. and A. B. and S. B. Leonardi, New Rochelle.

THE MANVILLE MANUFACTURING CORPORATION, New York. Capital, $300,000. To manufacture chemical fire extinguishers. Incorporators: S. Bennett, Jr.; R. Sherman and R. W. Evans, 14 Wall Street.

THE MERCHANTS FERTILIZER & PHOSPHATE COMPANY, Charleston, S. C. Capital, $25,000. To manufacture fertilizer and phosphate. Incorporators: E. H. Pringle, Jr., B. G. Pringle, F. E. Barron and A. F. Pringle, Charleston.

THE MERRIMAC VENEER COMPANY, Byram, Miss. Capital, $50,000. To manufacture paints, varnishes, etc. Incorporators: Frank and Robert Morrison and Thomas McCase.

THE METLSKIN COMPANY, Rochester, N. Y. Capital, $10,000. To manufacture chemicals. Incorporators: A. E. Van Houten, C. H. and G. B. Miller, Rochester.

THE NATIONAL REDUCTION COMPANY, Dover, Del. Capital, $1,100,000. To manufacture charcoal, tar and turpentine from wood, etc. Incorporators: Guy V. Ferguson, James H. Kirkpatrick, New York; Earle L. Woodward, Great Kills, Staten Island, N. Y.

THE NITRO CHEMICAL CORPORATION, Wilmington, Del. Capital, $2,000,000. To manufacture explosives of all kinds.

THE PEOPLES MUTUAL LEAD & ZINC COMPANY, Muhall, Okla. Capital, $1,000,000. To mine for lead and zinc. Incorporators: G. M. and W. C. Wolfe, and Thurman Ellison, Muhall.

THE PURITAN STEEL COMPANY, INC., New York. Capital, $50,000. To manufacture iron and steel. Incorporators: Herman Brasch, William J. Miller and T. T. Teichberg, New York.

THE RICHVALE FURNACE COMPANY, New York. Capital, $1,000,000. To manufacture furnaces. Incorporators: Samuel B. Howard, G. V. Reilly and A. W. Britton 65 Cedar Street.

THE SEQUOYAH OIL REFINING COMPANY, Dallas, Tex. Capital, $50,000. To engage in the production of oil and the refining of same.

THE STAR CHEMICAL MANUFACTURING COMPANY, Los Angeles, Cal. Capital, $10,000. To manufacture chemicals and allied products. Incorporators: Hyman Feder, K. M. Bonoff, D. A. Monheit and E. V Rosenkranz, all of Los Angeles.

THE STAYWITE COVERING COMPANY, Queens, N. Y. Capital, $10,000. To manufacture paints, enamels, lacquers and celluloid surface coating. Incorporators: H. Harjes, J. F. Hicks and H. J. Crofield, 560 Rogers Avenue, Brooklyn.

THE STEPHEN ENGINEERING COMPANY, Dover, Del. Capital, $500,000. To manufacture furnaces and appliances.

THE TRUMAN M. SMITH MACHINE COMPANY, Grand Rapids, Mich. Capital, $60,000. To engage in the manufacture of foundry products. Incorporators: T. M. Smith, Jr.; L. P. Rice and Gerald McCoy, Grand Rapids.

THE VOSS ALCOHOL EXPORT CORPORATION, New York. Capital, $50,000. To manufacture alcohol, etc. Incorporators: H. W. Voss, G. A. Moore, 27 William Street; R. E. Voss, 123 West Ninety-fifth Street, New York.

Construction and Operation

Alabama

BIRMINGHAM. — The Sloss-Sheffield Steel & Iron Company is planning for the early operation of its Hattie Ensley Furnace No. 2, under daily capacity of about 300 tons. Repairs made at the furnace have cost over $300,000.

BIRMINGHAM.—The National Cast Iron Pipe Company, which recently filed notice of an increase in its capitalization from $350,000 to $500,000, is planning for the immediate erection of additions to its plant to increase the present capacity. Included in the work will be a new steel and cement foundry building, about 50 x 200 ft., which will be equipped with cranes, cupolas and facing and drilling machines for flange pipe.

HOLLINS.—The Parkdale Graphite Products Company, recently incorporated with a capital of $100,000, has completed its organization arrangements and is planning for the immediate development of 200 acres of land. It is said the output of the plant will be approximately ten tons of graphite each hour. Headquarters of the company are at Talladega. R. G. Nickles is president and manager; A. H. Sawyer, Hollins, is construction engineer.

Arkansas

HARRISON.—The Kreuger-Mills Mining Company, recently organized by W. O. Kreuger and E. H. Mills, of Springfield, Mo., has acquired 300 acres of land in connection with a large plant and is planning for immediate operations for the production of lead and zinc. The company will also make improvements in the works to cost about $20,000.

California

BAKERSFIELD. — The Standard Oil Company is planning for the construction of a new machine shop at its plant at McKittrick.

BERKELEY.—Peet Brothers, manufacturers of soaps, are planning for the construction of a large new factory at their local works. Head offices of the company are at Kansas City, Mo.

MARTINEZ.—The Atlas Powder Company has acquired a large tract of land, consisting of 206 acres, just north of its plant, and it is reported that the property will be used for extensive additions to its present works. The property was secured at a price of $50,000.

SAN DIEGO.—The United States Shipbuilding Company has recently inaugurated active work for the construction of its proposed shipbuilding plant on property recently acquired on the tidelands, San Diego Bay. The company is said to be negotiating with the Emergency Fleet Corporation for the construction of ten steel vessels, with total capacity of about 90,000 tons, at the new plant. Adam Weckler is manager.

WEST OAKLAND.—The Southern Pacific Railroad Company is planning for extensive improvements and alterations in its creosoting plant to cost about $350,000. The plant will be completely modernized, and with extensions, will cover about 25 acres of land. The works will have a creosoting capacity of about 3,000 000 ft. of lumber per year. J. A. Barlow is assistant chief engineer.

Connecticut

STAMFORD. — The John Davenport Foundry Company is having plans prepared for the construction of a new two-story concrete factory building, about 90 x 300 ft., to be erected on Davenport Place. The estimated cost of the structure is $90,000. Henry Marvin, Main Street, Stamford, is architect.

WEST HAVEN.—The Consolidated Rendering Company, 69 North Market Street, Boston, Mass., is making rapid progress in the construction of a new one-story local plant, about 18 x 220 ft. U. G. Carmichael, 902 Chapel Street, New Haven, is the contractor.

Georgia

ATLANTA.—Plans have been completed for the erection of the proposed new plant of the Doss Rubber & Tube Company at Fort McPherson. The works will be about 55 x 142 ft., one-story, of stone and brick, and will have floor space of approximately 18,000 sq. ft. When completed the factory will have a capacity of 500 inner tubes and 500 casings daily. The Pittman Construction Company, Atlanta, is the contractor.

Illinois

BLUE ISLAND.—The American Wire Fabrics Company, 208 South LaSalle Street, Chicago, is having plans prepared for the construction of a large new local plant to cost about $200,000. Frank D. Chase, 122 South Michigan Avenue, Chicago, is the architect and engineer.

CHICAGO.—Rapid progress is being made by the Chicago Bearing Metal Company, 2234 West Forty-third Street, in the construction of a new one-story addition, about 102 x 226 ft., to its bearing metal plant, to cost $15,000.

CHICAGO.—The Hughes Electric Heating Company, Waller Avenue and Taylor Street, has taken out a building permit for the construction of a new one-story plant, about 87 x 250 ft., to be used for the manufacture of electric heaters.

EAST ALTON.—Construction has been commenced by the Consolidated Chemical Products Company on a new one and two-story factory, about 75 x 235 ft., to cost $80,000.

EAST ST. LOUIS.—The Durbin Automatic Train Connector Company, Pontiac Building, has awarded a contract to the F. Woerman Construction Company, Century Building, St. Louis, Mo., for the erection of a new foundry building on Bond Avenue, to cost $25,000.

Indiana

FT. WAYNE.—The Supreme Motor Corporation, Union Building, Cleveland, Ohio, is having revised plans prepared for the construction of a new one-story local plant, about 100 x 400 ft., to cost $300,000.

FT. WAYNE.—Rapid progress is being made by the General Electric Company in the construction of a new factory building at its local works. Contract has been awarded to the Bedford Stone & Construction Company, Fletcher Trust Building, Indianapolis, Ind.

HAMMOND.—The Standard Steel Car Company, Frick Building, Pittsburgh, Pa., has completed plans for the erection of a new one-story addition to its local machine shop, about 250 x 800 ft., of brick and steel construction, to cost $250,000. Contract has been awarded to the McClintic-Marshall Construction Company, Oliver Building, Pittsburgh.

Kansas

WICHITA.—The Benjamin J. Sibbitt Iron Company has acquired property on Santa Fe and First Streets, about 132 x 290 ft., for a consideration of $16,000, and is having plans prepared for the erection of a new one-story brick foundry, which will be operated in addition to its present structural works.

Louisiana

NEW ORLEANS.—The New Orleans Refining Company has acquired a large tract of land on the old Sarpy plantation, near New Orleans, as a site for the construction of a new oil refinery.

NEW ORLEANS.—The Gasoline Corporation has recently acquired a site of land having a frontage of about 1000 ft. on the Mississippi River and about 50 acres deep, and is said to be planning for the construction of a large new plant for the refining of gasoline.

Maryland

CURTIS BAY.—The Associated Chemical Company, manufacturer of fertilizer, etc., is planning for the construction of new additions and extensive improvements in its local plant. Headquarters of the company are at Hagerstown.

BALTIMORE. — The Bartlett-Hayward Company has awarded a contract to Morrow Brothers, Fidelity Building, Baltimore, for the construction of a new two-story brick, steel and concrete foundry at Scott and McHenry Streets.

BALTIMORE.—The Hess Steel Corporation is planning for extensive improvements and additions to its plant to provide for increased capacity, to include the erection of a new mill-construction plant building, containing about 19,000 sq. ft. of floor space, and a new administration building. The new equipment will consist of electric melting furnaces, cranes, pouring equipment, etc., for the production of electric-furnace alloy steel.

Michigan

GRAND RAPIDS. — The Tannewitz Works, 315-31 Front Street, have had plans prepared for the construction of a new two-story brick and steel addition, about 96 x 96 ft., to its factory and machine shop. Pierre Lindhout, National City Bank Building, Grand Rapids, is the architect.

LANSING.—The Lansing Chemical Company has awarded a contract for the erection of two one-story additions to its chemical manufacturing plant, about 50 x 50 and 50 x 100 ft., respectively, to William T. Britten, 821 West Ottawa Street, Lansing.

Minnesota

MINNEAPOLIS.—A new one-story brick foundry addition to its plant, about 195 x 297 ft., will be erected by the Gas Traction Foundry Company, 1907 Fourth Street. The structure will cost about $70,000. Plans are being prepared by W. L. Alban, Endicott Building, St. Paul.

Missouri

KANSAS CITY.—Contract has been awarded by the Oxygen Gas Company, Traders Building, for the construction of its proposed new one-story and basement factory, about 44 x 120 ft., to cost $60,000. A. G. Harper, Indiana Avenue, is the contractor.

ST. LOUIS.—The Wagner Electric Company, 6100 Plymouth Avenue, has awarded a contract for the construction of a new one-story plant, about 130 x 512 ft., to cost $60,000. The new works will be devoted to the manufacture of ammunition. W. M. Sutherland Building & Contracting Company, Syndicate Trust Building, St. Louis, has the contract for erection.

ST. LOUIS.—The American Manufacturing Company, 1026 South Eleventh Street, is having plans prepared for the construction of a new one-story brick and concrete power plant, about 60 x 80 ft., at East St. Louis, Ill., to cost $40,000. Klipstein & Rathman, Chemical Building, St. Louis, are the architects.

Nebraska

OMAHA.—The Sprague Tire & Rubber Company, Twentieth and Harney Streets, is having plans prepared for the erection of a new three-story and basement tire and rubber plant on Izard Street, between Eighteenth and Nineteenth Streets, to cost about $200,000. George B. Prinz, 1033 Omaha National Bank Building, is architect.

New Jersey

CAMDEN.—The New York Shipbuilding Corporation has awarded a contract to the J. S. Rogers Company, Moorestown, for the construction of a one-story addition to its plant, about 50 x 130 ft., to be used as a galvanizing plant. The structure will cost $10,000.

RIDGEFIELD PARK. — The British-American Chemical Company, 52 Vanderbilt Avenue, New York, has acquired the plant and property of the Tennessee Copper Company, Ridgefield Park, and is planning for the construction of several new additions, the entire works to be devoted to the manufacture of chemicals.

JERSEY CITY.—Fire, on Dec. 21, destroyed a portion of the plant of the George H. Segal Company, Inc., 139-141 Logan Avenue, manufacturer of chemicals, with loss estimated at approximately $40,000.

NEWARK.—Fire, on Dec. 22, destroyed the plant of the Newark Rubber Company, 192 Emmet Street, with loss estimated at $50,000, of which $30,000 is for machinery.

PERTH AMBOY.—The Roessler & Hasslacher Chemical Company is planning for the immediate construction of a new one-story addition to its plant, about 50 x 165 ft.

DUNELLEN.—The Crescent Color & Chemical Works, 1735 West Front Street, is having plans prepared for the construction of a new two-story addition to its plant, about 70 x 80 ft., to cost $10,000.

SOUTH RIVER.—The Para Products Company, manufacturer of rubber goods, is planning for the rebuilding of its plant recently destroyed by fire. The new works will be about 100 x 200 ft.

NEWARK.—Colgate & Co., manufacturers of soaps and perfumes, have announced the acquisition of a tract of twenty acres at Point Newark Terminal on which a large plant will be built and where many new hands will be employed. No definite steps will be taken as to the building of this plant until the end of the war. This property is not far from the Submarine Boat Corporation's shipyards, and is along the same shore line of the American Synthetic Dye Works, and other large industries. It is in the neighborhood of the new locations on the Passaic and Hackensack rivers recently acquired by the Ford Motor Company, the United States Steel Corporation, and the Niles-Bement Pond Company.

New York

COLLEGE POINT, L. I. — The American Hard Rubber Company, 11 Mercer Street, New York, has had plans prepared for extensive improvements and alterations in its local plant. Alexander Macintosh, 55 Bible House, New York, is the architect.

BROOKLYN.—The E. W. Bliss Company, Adams & Plymouth Streets, manufacturer of munitions, will build a new seven-story plant, about 200 x 380 ft., on property recently acquired on Fifty-third Street, near First Avenue, South Brooklyn. When completed the new plant will represent an investment of approximately $1,400,000.

BROOKLYN. — Preliminary plans are being prepared by Louis Leavitt, 454 Driggs Avenue, for the construction of a new three-story and basement varnish factory, about 100 x 125 ft., at Driggs Avenue and North Eleventh Street, to cost about $70,000. William A. Giesen, 104 West Forty-second Street, New York, is the architect.

BROOKLYN.—The National Lead Company, 111 Broadway, New York, has had plans prepared for the construction of a new three-story reinforced concrete plant on Gold Street, from Marshall Street to Hudson Avenue. William Higginson, 21 Park Row, New York, is the architect.

ALBANY.—Fire recently destroyed a portion of the iron foundry of George H. Thatcher, Pleasant Street, which was engaged upon Government work. It is said that the destroyed section will be immediately rebuilt.

TROY.—The Rensselaer Polytechnic Institute, Broadway, will build a new four and five-story addition to its chemical laboratory, about 43 x 112 ft., and plans for the structure, which is estimated to cost $120,000, are being prepared by Lawlor & Hasse, 69 Wall Street, New York.

BUFFALO.—Plans have been prepared by the American Car & Foundry Company, 380 Babcock Street, for the construction of a new paint shop at its works to cost about $12,500.

BUFFALO.—The Pratt & Lambert Company, Tonawanda Street, manufacturer of paints, varnishes, etc., has taken out a building permit for the construction of a large addition to its plant to cost $30,000.

North Carolina

MT. AIRY.—The Tar Heel Manganese Company, recently incorporated with a capital of $100,000, is planning for the immediate development of 80 acres of land for initial operations and increasing the capacity during the coming spring. W. P. Sinclair, Welch, W. Va., is treasurer.

MURPHY.—The Appalachian Iron & Mining Company, with plants at Blue Ridge and Ellijay, Ga., is planning for the installation of new machinery at its works, including portable compressors, tripod machine drills, gasoline locomotives, etc., for the mining of iron ore. S. Long of Etowah, Tenn., is president.

Ohio

AKRON — The Kelly-Springfield Tire Company, Kelly Avenue, has awarded a contract for the construction of a new two-story addition to its plant, about 48 x 87 ft., to cost $10,000. W. A. Franklin Sons Company, 327 Cuyahoga Falls Avenue, has the contract for erection.

AKRON.—The B. F. Goodrich Rubber Company, manufacturer of rubber tires, etc., will build a new one-story mill room addition to its plant, about 112 x 150 ft., to cost $20,000. Contract for erection has been awarded.

CINCINNATI.—The D. T. Williams Valve Company, Spring Grove Avenue and Township Street, has taken over the plant and property of the Queen City Brass & Iron Company, Spring Grove Avenue and Garrard Street, Camp Washington, for a consideration of $300,000. The Williams company is planning for the immediate operation of the plant in addition to its present works, to provide for the steadily increasing demands for its product.

BARBERTON.—The Portage Rubber Company, Barberton, is making rapid progress in the erection of its new local plant. The works are estimated to cost $75,000.

CLEVELAND.—The National Carbon Company has acquired property comprising about five city lots adjoining its carbon extraction plant at Scranton, Pa., and is planning for the construction of a large addition to provide for increased capacity.

COKE OTTO.—Plans are being prepared for extensive improvements and additions to the plant of the Hamilton Furnace Company, near Hamilton, to include the erection of a car dumper to cost about $175,000; a new water softening plant, $30,000, and a new ore bridge to cost $150,000. The new improvements, when completed, will represent an expenditure of about $500,000.

DAYTON.—Contract has been awarded by the Wright Aeroplane Company to Frank Hill Smith, Inc., 120 Broadway, New York, for the construction of a new one-story addition to its plant, about 300 x 1000 ft., to cost $100,000.

MANSFIELD.—A new one-story factory building will be constructed by the Phoenix Electric Company, Olivesburg Road, to provide for increased capacity. The structure, which will be about 50 x 100 ft., will cost $10,000. Contract has been awarded to Simon Small & Son, Bird Building, Mansfield.

MARIETTA.—Plans have been prepared by the Leidecker Tool Company, 119 Second Street, for the erection of a new one-story plant, about 100 x 175 ft., concrete and steel construction, at Westview, near Marietta. Foster Leidecker is general manager.

McDONALD.—The Carnegie Steel Company has awarded a contract to the Youngstown Foundry & Machine Company, Youngstown, for the installation of a new 10-in. hoop mill at its local works.

URBANA.—The Central Glass Company, which has taken over the plant of the Eagle Glass Company, has completed improvements and alterations at the works, costing about $100,000, and is planning to inaugurate operations at an early date.

Oklahoma

MIAMI.—The Miami Zinc & Lead Syndicate, recently incorporated with a capital of $5,000,000, has acquired the porperty of the St. Louis Mining & Smelting Company, including 1400 acres of mineral lands, and is said to be planning for the construction of several large mills and a smelter plant.

Pennsylvania

BURNHAM.—The puddling furnaces of the Logan Iron & Steel Company were closed temporarily on Dec. 20, due to coal shortage.

CATASAUQUA.—The Crane Iron Works has banked one of its stacks for lack of coke. As soon as conditions improve the plant will be reopened.

ERIE.—The American Sterilizer Company, Twelfth and Plum Streets, is making rapid progress in the construction of the new one-story brick addition to its plant, 50 x 70 ft., to cost $10,000. The Stader Conrath Construction Company, Palace Hardware Building, Erie, is the contractor.

PUNXSUTAWNEY.—Fire recently destroyed the plant of the Eldred Window Glass Company with loss estimated at $200,000. The company is planning for the immediate reconstruction of the plant.

READING.—The Reading Iron Company has completed improvements, including the relining of its Keystone blast furnace, and is planning to place the stack in operation at an early date.

MOOSIC.—Fire on Dec. 19, caused by an explosion, destroyed a portion of the plant of the duPont Powder Company, with loss estimated at $25,000.

WILLIAMSPORT. — The Valley Iron Works, 209 West Street, has awarded a contract for the construction of a new two-story plant, about 45 x 75 ft., to cost $15,000. J. V. Bennett & Company, 309 West Third Street, Williamsport, is the contractor.

Tennessee

HARRIMAN.—Joseph and William Baker have acquired the plant and property of the Harriman Mine Car Manufacturing Company and are planning for the construction of several new additions and extensive improvements to increase the present capacity.

NASHVILLE.—Reports from Nashville, Tenn., are to the effect that E. I. duPont de Nemours & Co. is planning to erect a big plant in Big Bend, near Nashville, it being stated that the plant will employ about 4000 persons. Whether this plant will manufacture dyestuffs or explosives has not been definitely stated. According to the Nashville Banner, Daniel Caufield, real estate purchasing agent for the duPonts, has definitely stated that the company would employ 4000 people at a plant to be located in Big Bend.

Texas

RUSK.—The Texas Steel Company, Beaumont, has acquired the Rusk foundry property for a consideration of $112,500, including iron furnace, pipe foundry, etc., and is planning for extensive improvements and the reopening of the blast furnace, to have a capacity of 120 tons of iron daily.

BROWNSVILLE.—The LaBlanca Sugar Company, recently organized with a capital of $500,000, has acquired the sugar factory of the LaDonna Sugar Company, near Donna, with 4000 acres of land adjoining the plant in Hidalgo County; also 8000 acres of land in Cameron County, and is planning for extensive improvements in the plant acquired to cost about $50,000. J. G. McDowell, Pittsburgh, Pa., is president.

Virginia

ST. PAUL.—The Clinch Valley Chemical Company, recently incorporated with a capital of $5,000,000, has had plans prepared for the construction of a large by-product plant. It is anticipated that the plant will be in operation early in the spring.

West Virginia

CHARLESTON.—The Powhatan Brass & Iron Works has awarded a contract to Glaize & Brother, Winchester, Va., for the construction of a new one-story foundry at its plant.

Wisconsin

MADISON.—The Four Lakes Ordnance Company, 2305 Waunesa Street, is making rapid progress in the construction of its new one-story plant, about 150 x 590 ft., which will be devoted to the manufacture of guns. It is estimated that the plant, when completed, will cost $1,000,000. The Austin Company, Euclid Avenue, Cleveland, Ohio, is the contractor.

MILWAUKEE.—The Milwaukee Paper Box Company, manufacturer of paper boxes and kindred products, is having preliminary plans prepared for the construction of a new plant to cost about $150,000, to provide for increased capacity.

MILWAUKEE.—The Liberty Foundry Company, 967 Grand Boulevard, has commenced the erection of a new one-story foundry, about 65 x 120 ft., on Watertown Plank Road, to cost $15,000. J. D. Morrison, 625 Sixty-ninth Avenue, West Allis, is the contractor.

MILWAUKEE.—The Gerlinger Steel Casting Company, specializing in the production of steel castings, has commenced the construction of two new additions to its plant, each 40 x 50 ft., to provide for increased capacity. John J. Gauser, West Allis, is the contractor.

Manufacturers' Catalogs

THE WILSON WELDER & METALS COMPANY, INC., New York City, has issued catalog No. 2, describing the Wilson system and giving considerable general information of value in welding.

THE AMERICAN HARD RUBBER COMPANY, 11 Mercer Street, New York City, has issued a very attractive catalog describing its line of acid pumps, piping and utensils.

Other New Publications

CALIFORNIA MINERAL PRODUCTION FOR 1916, with county maps. Bulletin No. 74 of the California State Mining Bureau, Ferry Building, San Francisco. Walter W. Bradley, author.

MATERIALS FOR THE HOUSEHOLD.—Circular No. 70 of the Bureau of Standards. Issued Dec. 5, 1917. Price 25 cents. From Superintendent of Documents, Government Printing Office, Washington, D. C. Contains valuable information for manufacturers of products used in the household.

Trade Notes

N. B. PAYNE has opened an office in the Havemeyer Building, 25 Church Street, New York, as an electric crane specialist, supplying new and used traveling cranes. Mr. Payne was formerly associated with Manning, Maxwell & Moore, Inc., New York.

THE ECONOMY ENGINEERING COMPANY of Chicago, manufacturer of tierling machinery and portable elevators, has established its own New York office at 85 Murray Street. The company was formerly represented in New York by the Standard Scale & Supply Company.

GRASSELLI CHEMICAL COMPANY TO INCREASE CAPITAL.—There will be a special meeting of the stockholders of the Grasselli Chemical Company on January 24, at which the stockholders will vote on a proposition to increase the company's authorized capital from $20,000,000 to $50,000,000. The plan is understood to include an increase of the authorized issue of preferred shares from $5,000,000 to $15,000,000, and the common stock from its present issue of $15,000,000 to $35,000,000.

STANDARDIZATION OF DYESTUFFS.—Upward of 200 company representatives and individuals from all parts of the country have expressed their intention of attending the two-day meeting which is to be held in Rumford Hall of the Chemists' Club, No. 50 East Forty-first Street, on January 22 and 23 to further the movement which has been initiated to standardize American dyestuffs and aniline colors. Practically all of the leading manufacturers and dealers have approved the movement and promised to attend. H. Gardner McKerrow, manager of the textile department of E. F. Drew & Co., who has handled all of the details of the proposed meeting, will open the convention as temporary chairman.

In addition to standardization of dyestuffs and colors, the meeting will give consideration to several other matters of prime importance to the dye and dyestuffs industry. Among the latter may be mentioned the question of tariffs, arbitration of disputes, and protection of contracts. Numerous other matters which properly come within the function of a trade association will be discussed, as it is stated that the initial idea is to form a "National Dyestuffs Association," which will fill the same relation to the industry as do various cotton and woolen and other trade associations to their industries.

NEW SWEDISH DYE COMPANY.—The A. B. Kemisk Industrie, a new company, has taken over the undertaking carried on for a year and a half under the same title by A. V. Holson, for the production of coal-tar dyes. The new company proposes to extend the works so as to be able also to produce chemical materials of importance to Swedish industries, particularly for the manufacture of munitions. It is believed that it will be possible to begin the manufacture next autumn of about 100 different dyes. The company will have the largest laboratory in Sweden and will employ a staff of from 25 to 30 chemists, whose numbers will be gradually increased. The share capital has been fixed at 5,000,000 kr. ($1,330,000). It is stated that the works have already produced a number of dyes which in every respect appear to compare well with German products. The Swedish requirements amount to 10,000 tons per annum, and to those attention will first be paid. As raw materials to be used are principally mentioned benzol from the Swedish gasworks, acids, bases, salts, etc., which for the most part are produced in the country, which also is able to provide most of the machinery and plant required. The Superfosfat Fabriks A. B., of Stockholm, which is the principal Swedish chemical industry company, has an interest in the undertaking.

OTHER NEW SWEDISH INDUSTRIES.—Scarcity of fats of every description has caused the creation of new industries in all European nations for the production of fats of every kind from sources hitherto considered unpromising. In Malmo, Sweden, a new corporation has been organized named the Aktiebolaget Feddindustri, with a capital of $1,340,000 to produce fats from bones and any other material that yields fat good for soap and other industrial purposes.

A corporation named the Höganäs-Billesholm Aktiebolaget is investigating an invention for producing aluminium out of the clay found in the vicinity of Höganäs, Sweden. A new factory will probably be built near Trollhättan, which will be able to utilize economically about 6000 hp. from the large waterfalls at that place.

One of the industries developed by the war is the Svenska Elektron, which was organized at the end of 1915 with a capital fo $53,600. The capital is now being increased to $268,000 to carry on the additional business that is constantly developing in the silver and other metal specialties made by the company.

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City Gas and Modern Warfare

THE exigencies of war are likely to familiarize every domestic user of gas with one phase of our great chemical industry and its relation to modern combat. We refer to the recovery of toluol from city gas and its conversion into trinitrotoluol, TNT, the high-explosive of modern warfare. The shortage in this commodity, which has been recovered largely from by-product coke-oven gas, will be brought home to every user of city gas in this country before the campaign for its production is over. Gas consumers thus become vitally interested in the production of explosives, and in the end it is likely that they will profit by changes in gas standards which are otherwise desirable and which war is only hastening.

Two different standards exist for determining gas quality. Almost every city has adopted one, and some have both. There is the candle-power standard, which is now considered antiquated, being a relic of the days before the incandescent mantle was known. Opposed to this is the more modern and scientific heating-value standard which grades gas in terms of British thermal units. Now toluol and benzol are important factors in both the heating and lighting values of city gas. Hence the removal of these hydrocarbons, or particularly toluol, will reduce both the lighting and heating values below the standards prescribed in various cities. This has necessitated a revision of the standards already in effect by city ordinance, and in some cases has involved the consent of public service commissions.

From estimates made by the U. S. Bureau of Standards as to the influence of toluol recovery on gas quality it appears that candlepower is more seriously affected than heating-value by the removal of toluol. This suggests the elimination of the candlepower standard altogether and the substitution of a heating-value requirement; and since there are other reasons for abandoning the older standard in favor of the newer, the effect of the war is to hasten the adoption of an otherwise desirable practice.

Thus are peaceful pursuits modified by the requirements of war. Hitherto city gas has been just a convenient form of fuel to be had for the turning of a valve; suddenly it becomes an important source of a war necessity. That we have not always recovered toluol from city gas and thereby been prepared for the present emergency is due to economic conditions and not to lack of knowledge or ability. Like many other by-product industries which we have left to our European neighbors, toluol recovery has not appealed to us. It served us best in the gas where it was originally formed, and there was no good reason for taking it out. Technical industry is replete with similar instances.

The Dyestuff Association

THE Dyestuff Association of America has been duly organized and we wish it well. When those interested in the manufacture and sale of anything meet to consider the general welfare it is usual that preliminary negotiations have more to do with who shall guide than with who shall contribute. In this respect the participating manufacturers of dyestuffs and intermediates felt that their investments and interests required that only manufacturers should be members, while dealers might be associate members without voting power but with single representatives on leading committees. This was a wise provision, because in the dyestuff industry, while manufacturing and selling very properly go hand in hand, the economic problems have to do with manufacturing. The art of selling dyes and giving the proper service with sales is difficult and it has been to many a profitable undertaking, but it sinks into unimportance when compared with a well co-ordinated, native manufacturing industry.

Before the great war, dyestuffs were principally made in Germany and sold here, originally through German agencies; and even down to 1914 the selling was in good part under German control. It was a business replete with German traditions, being at once efficient and rotten. The bribery of dyers was an established custom. "They all did it," said an old dealer, "and the only difference in this connection between Americans and Germans who engaged in the practice was that the Americans knew it was wrong and the Germans didn't." The nomenclature of products still has the ear-marks of the undesirable sort of German *Kultur*. It is unconscionably ugly and devoid of all enlightenment or fancy except in so far as it was designed to deceive.

The association will now have to find itself. Able men with high ideals are earnestly interested. Reforms in pre-war selling practices are urgently needed. just as is the development in manufacturing. The tariff should be amended by the elimination of the joker that was inserted into the bill at the last moment whereby alizarine and indigo products were excepted from the specific duty; but when that is accomplished let us hope that the association will devote itself in the maximum to research and development and in the minimum to profits by acts of Congress. The start is auspicious.

Tendencies in Copper Milling

IT HAS been observed that there are prevailing styles in ore-dressing which change from time to time in accordance with ideas evolved through research and experiment. These changes may be abrupt, but are more often gradual and usually there is a transition period during which tendencies can be observed which later become established custom. Copper milling has been particularly responsive to progressive suggestions, and for that reason has been one of the most interesting branches of ore treatment.

The principal tendency observed in copper milling for some years past has been to eliminate stage-crushing and to devise flow-sheets producing no coarse concentrates. In this manner preliminary crushing by rolls followed by regrinding of jig tailings in edge-running mills is apparently being supplanted by a finer original reduction by disc crushers and tube or ball-mills. One notices a tendency for the trommel to be replaced by the impact or shaking screen. Mill men are also beginning to appreciate the necessity of adequate settling capacity to catch the last portions of mineral from spent water, and huge tanks for settling, thickening and de-watering are quite common.

Flotation is used on every hand, either as the main concentrating device, or as an expedient to recover mineral formerly lost in slimes and tailings. The beauty of simplicity seems to have been attained in some of the latest installations, where the flow-sheet consists of the four steps: crush, float, thicken, filter. This wonderful process has enabled the mill-man to produce a tailing extraordinarily low in value, the majority of these losses being of oxidized particles which will not float. He is therefore turning his attention to the task of recovering these last modicums of value—indeed, the outstanding problem in milling practice today seems to be to devise some economical and practicable method for handling ores which contain a mixture of copper oxides and sulphides. This problem is usually attacked by hydrometallurgy; sulphidizing flotation (as practiced at Hurley and elsewhere) may come under this head, since the oxide probably goes first into solution, even superficially, before being precipitated as a sulphide.

These tendencies in the mill are responsible for the increasingly large quantity of fine concentrates sent to the smelter, shipments often consisting of large tonnages of a sticky filter-cake containing upwards of 15 per cent of water. Many revisions in smelting equipment are due to this cause. Particularly in the roasting department, pan feeders are necessary to deliver a constant quantity of this wet material to the furnace. The large Herreshoff or Wedge furnace, or a modification of these styles, is now being installed almost exclusively, and in some cases supplanting the smaller McDougall roasters. The top of these furnaces is utilized as a preliminary drying hearth, while auxiliary heat is usually necessary to complete the roast. Separate coal-fired fire-boxes, powdered-fuel burners, and oil torches are each successfully used for this purpose. The ample drop-hole area afforded by the larger furnaces is also essential to prevent huge dusting losses when handling the extremely fine materials now so prevalent.

The Fuel Order

WE SHALL comment but briefly on the now famous fuel order of Dr. Garfield. It has received attention, respectful and otherwise, at the hands of editors throughout the country and has generally been condemned. We should not lose sight of the fact, however, that the great majority of the critics have not been handicapped by any personal knowledge of the underlying causes and have, therefore, been able to discuss the subject at length and without embarrassment. Our own impressions were gathered at an audience which Dr. Garfield gave to a small group of editors of McGraw-Hill engineering publications.

The fuel order was a military necessity. As such it is not susceptible of explanation in detail without disclosing information to the enemy. It was not designed primarily to save fuel, but to improve conditions in railroad transportation, the demoralization of which was the chief contributing factor to our difficulty. We have

not lacked fuel, but engines and cars with which to handle the freight. The same situation would have developed in some degree if there were no war. It is the urgency of the situation which impresses our lack upon us. The shortage of motive power and rolling stock is attributable, in turn, to the government's policy of the past few years which has resulted in starvation of the railroads. Failure to heed the railroads' requests for an income which would enable them to operate profitably and maintain their equipment in good condition left them unable to serve the country in its crisis.

To all this should be coupled the fact that, with coal in great quantity loaded in cars and standing on the tracks, the Fuel Administration was unable to get a priority order for shipments of fuel to the seaboard, while other favored commodities continued to arrive at coast ports and congest the terminals. This failure to observe a proper sequence in the receipt of coal and other products made it impossible to bunker the ships that were loaded and waiting to transport *materielle*.

The administration of our fuel resources has not been altogether satisfactory, but the trouble has been a lack of co-ordination at Washington—the same trouble, in fact, which is now being revealed, and we hope remedied, in other departments. Recall, for instance, the ill-advised price-fixing which was done hastily to forestall independent action by state governors, the immediate repudiation of the agreement by the Secretary of War, the consequent confusion among consumers and failure to lay in stocks anticipating a lower price, the refusal by Judge Lovett of a priority order on coal and the failure to observe a proper sequence in consignments of fuel and commodities to the seaboard—recall these and the railroad situation, and we can find ample reason for the fuel order. It was inevitable. The weather having been unfavorable to securing the best results from a weakened transportation system, we may expect other closing orders and embargoes on freight.

Too Little Railroad Regulation

NO, THERE is no misprint in the caption. If there is a mistake it is by the editor, not the printer. Most of the talk lately has been of "too much railroad regulation." Perhaps with a qualifying phrase the statement might be correct, that there has been too much regulation of its kind. What occurred was that legislation did not keep pace with the progress of events. The original Interstate Commerce Act, which passed its thirtieth birthday last year, was intended, and very properly, to make railroad charges uniform and eliminate the giving of rebates. That was quite necessary, but other things have since come to be necessary.

The theory of railroad regulation was correct; the application very faulty and altogether incomplete. The theory was that railroads were essential for the development of the country, that the business of the country depended largely upon the railroads, hence the federal government should regulate the railroads. The sugar question is quite a familiar one at this time. It is being regulated, but the public is not satisfied simply with the price being held down. It wants sugar. The price is one thing, the securing of the sugar another. The former is of no use without the latter.

In the case of the railroads only the price has been regulated. No effort has been made to see to it that the public is furnished the service. The railroads have made various pleas to the Interstate Commerce Commission in the past few years that they be allowed to advance rates, pointing out that they were not in position to increase their facilities by reason of insufficient remedies. They did not offer to make a bargain with the commission that if they were granted such and such rate advances they would buy so many locomotives and so many cars, and would build so much track. If they had made such an offer the commission was not authorized by existing law to bargain with them, nor was there any public sentiment that would suggest to Congress the giving of such power to the commission. It matters not whether the increase in revenue would itself have been used or would have been simply the means of improving railroad credit. The matter has usually been looked at as "the railroads borrowing money," but it is broader than that. The issue has been that of capital seeking railroad investment, whether it was in the form of money being loaned to an existing railroad or in some other form.

Railroad men are human, and they have tried to make the best of the situation in which they found themselves. The people decided that rates should be regulated and so they were regulated. The railroads let it go at that.

The people should have decided that the freight-moving facilities of the country should steadily increase year by year with the growth of the country, and should have made provision that this should occur.

The war is merely an incident. War is not the only thing that makes a people busy. We might easily have had the foundation for greater industrial activity than we have if there had been no war. The full activity would not have resulted because men would not work against such odds as they now encounter and strive to overcome because it is war, not business.

Some who comment upon the situation observe that the railroad congestion is greatest at the Atlantic seaboard, and apparently assume that this represents one of the dislocations of war because we are exporting material to our Allies and our own troops. There is much less merchant shipping than there would be at this date if there had been no war, and everyone is counting upon a very large increase in the world's merchant marine after the war, also upon a very heavy foreign commerce for the United States. That would tax the railroads much more than prosecution of the war is taxing them.

What has occurred is simply that the war has opened our eyes to the fact that the existing railroad facilities are insufficient for normal industrial activity. The country has not enough service. Limiting the wages of the servants is not sufficient. Enough servants must be provided. The Director General of Railroads recently testified before a Congressional committee that the railroads might have to be improved, under government auspices, to the extent of a billion and a half dollars being expended. In the light of such a possibility, a prospect indeed rather than a possibility, discussion of how and when the railroads shall be returned to their owners is not to the point. The country needs the traffic facilities both now and after the war. It is a detail who shall own and operate the equipment, and one that can be considered much more intelligently later than at present.

Presentation of Perkin Medal to Auguste J. Rossi

An Account of the Exercises Under Auspices of the New York Section of the Society of Chemical Industry, with Review of Mr. Rossi's Life and Work

IN accordance with an annual custom established in 1906, the New York Section of the Society of Chemical Industry made its award of the Perkin Medal at the Chemists' Club on Friday evening, January 18. The recipient was August J. Rossi, whose contributions to the metallurgy and uses of titanium have distinguished his interesting professional career since 1864.

Dr. Jerome Alexander, chairman of the section, presided. Both the dinner in the Chemists' Club dining room previous to the meeting, and the meeting itself were attended by a large and representative gathering. Rumford Hall was appropriately decorated for the occasion with American and French flags.

Introductory Remarks by Dr. Jerome Alexander

Nothing could be more illustrative of the cordial solidarity that unites us to our Allies, England and France, than this evening's meeting, for here before the New York Section of a British society we are about to award the Perkin Medal to Auguste J. Rossi, a native of France.

France! How the heart of every true American, yes, of every true democrat throughout the world, leaps at the mention of that name! Fair are her fields and beautiful her cities, but France is much greater than all these—her artistic, literary, scientific and spiritual gifts to humanity and civilization have made us her debtors for all time to come, and to-day the civilized world is fighting under her slogan of "Liberty, equality, fraternity."

As a consequence of this dreadful war and under the lash of its stern necessities, we have fortunately been brought in closer relationship with our French fellow chemists. For some months past we have been planning the formation of a New York Section of the French Société de Chimie Industrielle, the sister society of the British Society of Chemical Industry, and to-night, immediately following our meeting, it will be formally organized.

We will therefore proceed with our program, and hear an account of Mr. Rossi's life and work from a gentleman well known to you all, Mr. Francis A. J. Fitz Gerald, past president of the American Electrochemical Society.

Auguste J. Rossi

Dr. A. J. Rossi and His Work

By Francis A. J. Fitz Gerald

IT was, I think, in the year 1899 that I first made Dr. Rossi's acquaintance. There was much speculation in Niagara Falls at that time as to what he was doing. In those days there was always much gossip whenever some new work was started at Niagara Falls, for it was still in the early period of power development, before the MacFarlands and politicians got busy, and we were all watching eagerly the rapid electrochemical developments—aluminium, carborundum, caustic soda and chlorine, calcium carbide, etc. Wonderful stories would float about as to what newcomers were doing. When the Oldbury Chemical Co. started, the most astonishing stories were afloat, caused, I think, largely by the high brick wall which surrounded the factory. It was told with bated breath that this works was engaged in the manufacture of cordite by a new and secret process, and that you could not get inside the brick wall except over the body of an armed guard.

I cannot recall now what various stories were told about some remarkable work in the Porter house and the old stone barn which stood where the Acheson Graphite Company's plant now is, but these were sufficiently startling and all agreed that it was a French chemist named Rossi who was working on some new invention.

I soon made Rossi's acquaintance, for in the electrochemical work of those days there was a fine spirit of co-operation which indeed has become to a great extent permanently characteristic of Niagara Falls, and before long I got to know him very well. During visits to him I learned a great deal about his researches on the smelting of titaniferous ores, about the experiments he was then making on the manufacture and use of ferrotitanium and about many other chemical and engineering works with which he had been associated in his varied professional career. Although I may repeat some things which Dr. Rossi speaks of himself, I believe you will be interested in a brief history of his work.

In the year 1855, at the early age of 16, Rossi graduated from the University of France with the degree of

Bachelier ès Sciences et Lettres, and four years later, after he had also graduated from the École Central of Arts and Manufactures, where the studies covered mechanical, civil and metallurgical work, he came to New York. Here he soon obtained a position as assistant engineer with the Morris & Essex R. R., holding this until 1864, when the railway was taken over by the D., L. & W. After this he got a job which kept him busy for a year, making the survey of a property in Boonton, N. J., which was to be converted into a park under the direction of Mr. Calvert Vaux, the architect of Central Park, New York. Next we find him engaged in building a railway to the Boonton Iron Works, but when Fuller, Lord & Co. of that concern found out that Rossi had studied chemistry and metallurgy at the École Central they put him in charge of a laboratory at the iron works.

It was here that Rossi's attention was first called to titanium, for the ores used in the blast furnaces at the iron works were magnetites from Morris County, N. J., containing in the best samples about 1 per cent titanic oxide and in others 2.5 per cent or more. Beyond noting the existence of titanium in the ores Rossi was not particularly interested in it until he met the work of Professor Cook, the state geologist of New Jersey. This work called attention to the existence of titanium in nearly all the New Jersey ores, from fractions of 1 per cent to as high as 15 per cent titanic oxide. Professor Cook also established a relation between phosphorus and titanium in the ores, low phosphorus apparently going with high titanic oxide content. This set Rossi to work hunting up all the scanty—and, incidentally, very contradictory—literature he could find on the subject of titanium. None of this work was of any practical importance so far as the running of the Boonton Works was concerned, but several years after he had left his metallurgical work to devote his attention to tests on the pumping engines at Fall River, to calculations of the stability of the Beaver Bridge dam, to work on refrigeration and the manufacture of ice-making machinery, his researches on titanium became of value, because of a lawsuit in relation to his old firm of the Boonton Iron Works.

This lawsuit was of great importance so far as Rossi's future work was concerned, as it no doubt established his reputation as an expert in the melting of titaniferous iron ores. Thus, after Rossi had established an office in New York as a consulting engineer, and when in 1890 Mr. James McNaughton was interested in the development of the immense titaniferous ore deposits of the Adirondacks, it was to Rossi that he went for advice. Since that date Rossi has devoted most of his time to titanium.

The problem presented in this case was a study of the feasibility of smelting the titaniferous ores of the Adirondacks. Rossi, as a result of his researches years before, was well acquainted with what had been done in Europe in this field, and of special interest were the records he had of some blast furnaces near Stockton-on-Tyne, England, where ores running as high as 35 per cent titanic oxide had been smelted successfully by forming a slag that consisted of a silico-titanate of lime. This, of course, involved adding considerable quantities of lime and silica to the charge. Here lay the great objection to the Stockton-on-Tyne practice, for on account of the low iron content of the ore it was necessary to make about four tons of slag for one ton of iron.

Rossi told his client that success with the Adirondack ores could be obtained provided that the titanic oxide could be slagged off without using an enormous excess of fluxes, and that so far as the pig iron produced was concerned it would probably be of a very superior quality.

The upshot of the consultation was that Rossi went to examine the ore deposits and two small blast furnaces which had been run there by Mr. MacNaughton's grandfather from 1840 to 1858. In a curious old iron chest Rossi found the blast furnace records. Studying these and knowing the composition of the ore, the fluxes added and the amounts of these going into the charges of the old blast furnaces, Rossi found that the practice of the Stockton-on-Tyne furnaces had been anticipated. He also found that the iron produced was of such superior quality that a gold medal had been awarded it in the great London Exhibition of 1851. Moreover, certain steel made from this iron won high commendation from the navy yards of Springfield and Washington, the report stating that it compared favorably with the best Swedish steel.

Rossi then began a series of experiments on slags with the object of replacing silica with titanic oxide in the normal blast furnace slag, and following his success in this direction, built what might be described as a laboratory blast furnace in which several hundred pounds of excellent pig iron was made from the titaniferous iron ores. Next followed a small blast furnace built at the New York Car Wheel Works in Buffalo, where the Mill Pond ore, running 16 to 17 per cent iron, was successfully smelted.

In this way Rossi did the pioneer work in demonstrating the value of the great ore deposits of the Adirondacks in 1894. Twenty years later we find this work confirmed by Mr. Frank E. Bachman, general manager of the MacIntyre Iron Company, Port Henry, N. Y., in an interesting paper, "The Use of Titaniferous Ore in the Blast Furnace," presented to the American Iron and Steel Institute, October, 1914.

Turning now to ferro-titanium: Rossi was convinced from what he had observed in the work on smelting titaniferous ores that titanium had a beneficial effect on the manufacture of iron. A natural deduction from this was that an alloy of iron and titanium would be of value for the treatment of iron and steel in the process of manufacture.

This led to a series of experiments in small electric furnaces and finally to the construction of larger furnaces in Niagara Falls in 1899, where considerable quantities of ferro-titanium were manufactured, thus permitting of a great number of tests being made on a large scale in steel works and foundries.

This may be considered as closing the experimental period in the development of the manufacture and use of ferro-titanium. Rossi had now convinced himself of its value and the next problem was the education of others in its use.

I shall not go into the consideration of the commercial development of titanium, but merely discuss the principal causes of the great difficulty Rossi experienced in convincing the technical world of the value of his invention.

Perhaps this may be most vividly shown by means of an analogy presented by the practice of medicine.

There are a number of drugs of known value, some of them absolute specifics in the treatment of human ills, but every year we have added to our drug list a number of new medicines. Some of these are at once recognized as of real value by a few, but it often happens that their general recognition is delayed by the exaggerated enthusiasm with which they are greeted at their first appearance; moreover, it frequently happens that the injudicious use of the new drug gives it a bad name. Now, there cannot be any doubt that the very same causes which often delay true appreciation of a new medicine existed in the case of ferro-titanium. Among some there was an unwarranted enthusiasm as to the field of its usefulness and there were plenty of examples of complete failure in its application due simply to ignorance of the proper methods of using it. While, therefore, the value of ferro-titanium has always been recognized by some, there existed for a long time a prejudice against it in the minds of many, and in some quarters this exists even to-day. Thus, in spite of all Rossi showed as regards the possibilities of titanium seventeen years ago, skepticism was for long very general and is not yet completely eliminated. I hope, therefore, that you will pardon me if I call attention to a brief note I made some three years ago on certain statistics in regard to the use of titanium in rail steel, which I think very clearly disposes of the assertions made at that time that titanium has no effect on steel.

In this note are given the statistics of 155 heats, representing the production of 9,000 tons of rail steel, in some of which titanium was used while in others it was not. Where no titanium was used only 36 per cent of the steel came within the particular specification limit. Where 0.053 per cent of titanium was used, 43 per cent passed; with 0.077 per cent titanium, 84 per cent, and with 0.10 per cent titanium, 100 per cent passed.

In the earlier days of the exploitation of titanium the chief drive was made on its use in rail steel, and the data I have given show something of what can be done in that way. But of recent years much greater efforts have been expended in applying titanium to miscellaneous steels. Thus in the last ten years the ratio between titanium going into other kinds than rail steel has enormously increased, for while a decade ago the miscellaneous applications were only 12 per cent of the total they are now 96 per cent and have increased in volume about 150 times.

Thus Dr. Rossi, after more than a quarter of a century of work followed with the greatest perseverance, and undaunted by difficulties of all sorts, has not only shown what can be done with the titaniferous iron ores formerly regarded with distrust by the iron smelter, but has demonstrated that the very element supposed to make these valueless can actually be used for improving the manufacture of the metal they yield.

DINNER AT CHEMISTS' CLUB PRECEDING PRESENTATION OF PERKIN MEDAL

Address of Presentation

By Wm. H. Nichols†

THE world is beginning to get a gleam of what it owes to the chemist, and the chemist himself is beginning to be better understood. As a rule he works so much in the quiet of his laboratory and without the aid of that publicity which is such a prominent part in our life to-day that many of his most important discoveries are made known only to his fellow chemists, who in turn incorporate them in their own fund of knowledge and thus make use of them. Once in a while, however, something very striking comes out of a laboratory and attracts attention by its novelty or by its usefulness, or both. Under this category comes the wonderful dis-

†Past-president Society of Chemical Industry, President American Chemical Society.

covery of young Perkin, which has given the world, through those who have succeeded him, the great synthetic dye industry, the long list of synthetic remedies, and the various contributions to the "gentle art of war," which have followed Perkin's original work. What wonder, therefore, that when fifty years had elapsed, the chemists of the world should fittingly celebrate the work of the young Englishman, and what wonder that the occasion should be seized upon for the founding of a medal to be given to those who, following Perkin, should give to the world something of themselves which should forever be of great value to all mankind! Thus the Perkin Medal was founded, and thus it has annually been bestowed upon some great man who has made the world a better place to live in because he has lived in it himself.

Since the founding of the medal we have been exceedingly fortunate in having it presented annually by our own Professor Chandler, who was the first American selected to fill the great office of president of the Society of Chemical Industry. We have been in the habit of looking forward to these annual occasions, and the part which Professor Chandler would take in them, and I am sure we all greatly regret that he has not found it practicable to be with us to-night to assume this duty which we are so in the habit of associating with him. Unfortunately his health does not permit it, but let us hope that next year, and for many more to follow, he will stand in this place and perform this act in his usual graceful manner. It, therefore, falls to my lot as the next succeeding president to present the medal, and this task I undertake with great diffidence, feeling, as I do, the great disappointment which you all sustain in not hearing from the grand old man himself. It is not, however, the first time in which I have undertaken this work, as I had the honor of presenting the first Perkin Medal to Perkin himself during the jubilee celebration in New York.

It is particularly appropriate that this medal should be presented at one of the stated meetings of the New York section of that great English Society of Chemical Industry, which counted among its presidents so many great Englishmen, including Sir William himself. During the recent terrible years the members of this society have almost remade Great Britain from a chemical standpoint. Similar work of the highest grade has been accomplished by our French brethren. American chemists have taken great interest in the British society, and they are now to have an opportunity of doing similar work for the Société de Chimie Industrielle, the New York section of which is to be formed to-night. We have always had a warm place in our hearts for our French friends, and I am glad that we are going to have an opportunity of again proving this, if any proof be necessary.

You have heard from Mr. Fitz Gerald a statement of some of the work which Dr. Rossi has done, and it is not my intention to add to that list a single statement. If Mr. Fitz Gerald has omitted anything, Dr. Rossi himself will please supply as much of the deficiency as his modesty will permit.

Dr. Rossi, there have been several candidates for the honor which is to be conferred upon you to-night. The claims of each have been carefully weighed by a committee, whose only desire has been to select the candidate best qualified to receive the medal this year when everything has been considered. You have been their choice and are, after a long life full of hard work and the usual disappointments that come to every successful man, to receive the greatest reward which your fellow chemists can bestow upon you. You are joining a body of very brilliant men. You may well feel gratified that those who know best consider you worthy of the honor of that company, and in token of that selection I beg to express to you what I am sure is the thought of every man in this room, and of every other who knows your word, our hearty congratulations on a life well spent, and our cordial *bon voyage* as you turn your face to the setting sun. Coupled with this is the hope that you have before you yet many days of usefulness, and that you will be able to return our confidence with something of even greater value than what has gone before. With a heartfelt respect of the entire chemical fraternity, and a handclasp as its token, it is my privilege to present to you the Perkin Medal of 1917.

In accepting the medal Mr. Rossi expressed his heartfelt gratitude to his fellow chemists for the honor they had conferred upon him, and his appreciation of the fact that, after all, the award was not so much for personal merit as it was a recognition of those qualities of perseverance, thoroughness and devotion to science which mark all genuine research. He then gave an interesting account of his experience in the metallurgy of titanium. An excerpt of his address follows:

Development of the Metallurgy of Titanium

By Auguste J. Rossi

My special attention was directed to the possibilities of titaniferous iron ores in 1890 by Mr. James MacNaughton, a graduate of Yale interested in the immense Adirondack deposits as an inheritance from his grandfather, Mr. MacIntyre. These deposits were of such a magnitude that Mr. Birkinbine, then president of the American Institute of Mining Engineers, said of them at the Montreal meeting of the Institute in 1893: "Providence seems to have placed these titaniferous deposits right where they are the most inviting * * * on the headwaters of the Hudson river." I had been directed to Mr. MacNaughton by Professors Chandler and Ricketts as one who could give information on this subject, for I had had occasion previously to write a paper entitled "Titanium in the Blast Furnace" for the American Chemical Society.

Having been for some eleven years (1864-1876) technical director of the Boonton blast furnaces (Boonton Iron Works—Fuller, Lord & Co., proprietors), I knew from actual practice that the presence of titanium oxide (TiO_2) to an average of 1.5 per cent in the Morris County, New Jersey, ores, which we were smelting, and of some 2 to 2.5 per cent in our slags, had had absolutely no effect on the working of our furnaces or the behavior of our slags as to fluxidity and fusibility, so much so that I even ignored its presence and considered it as so much additional silica in the ores.

And still when the question arose of smelting these ores, alone or in mixture, one could read in the proceedings of a well-known scientific technical society "that 1 per cent of TiO_2 in a slag was enough to make it pasty to impossibility of tapping!" The advance copy of the paper (in my hands) says "that the slags had to be pulled out with tongs." How could young men new in the profession be blamed for being skeptical about the

smelting of this class of ore after such statements as I have quoted *verbatim?*

In 1876 the death of the two owners forced the closing of the Boonton Iron Works. The furnaces were blown out but not dismantled. Workmen and all had to leave and the small town was deserted for several years.

Later on in the 80's Mr. Eckert of Reading, Pa., who was making there what is called stove iron, having decided to use our puddled cinders, of which we had years of accumulation, with some of our ores containing 2 per cent TiO_2, leased the two blast furnaces which were still standing, with all the blowing apparatus and appurtenances. They made a failure of this run for technical reasons foreign to my subject and which could easily have been foreseen by one familiar with blast furnace work. However, having stopped the furnaces after a very few months' run, they tried to get out from their contract binding them to use a stipulated number of puddled cinders and ores by claiming that the presence of TiO_2 in our cinders and ores had been the cause of their failure. I was retained as an expert by the estate and had no difficulty to prove by my books of analyses and statements of founder and others that the presence of TiO_2 to the extent of their own analyses was in no way greater than the amounts which I had found during an eleven years' practice to have had absolutely no effect on the working of the same furnaces. They had to compromise and pay a heavy forfeit. I have entered into these details to render intelligible what follows.

The suit came before the Chancellor of New Jersey and I have on hand the brief submitted by the plaintiff, containing all sworn testimonies of their experts.

One of the experts, manager of one of the Durham furnaces (Cooper, Hewitt & Co.), testiled under oath that 0.75 per cent of TiO_2 in an iron ore rendered it unfit for blast-furnace purposes, as it would be only a matter of a short time before the furnace would be "clogged up" if the use of the ore were not stopped. Another(also a manager of a Durham furnace, testified under oath that not 0.75 per cent but 0.25 per cent of TiO_2 in an iron ore precluded its use in a blast furnace, it being merely a matter of a little longer time before the furnace would be clogged up. Mr. Eckert testified that "from his twenty years' practice in iron-making in blast furnaces not 0.25 per cent but *traces (sic)* of TiO_2 were sufficient to produce the same result as above mentioned.

Repeated Success in Smelting Titaniferous Iron Ores

This is only one of the many examples of the criticisms, prejudices and objections I met in my fight for these much abused ores. Such was the encouragement I found in the profession! Then in 1894, at the New York Car Wheel Works, Buffalo, N. Y., in a small furnace of three to four tons daily capacity, I melted, without mixture, titaniferous iron ores from the Adirondacks, containing 15 to 18 per cent TiO_2 and 55 to 56 per cent metallic iron. The slags as run from the furnace analyzed 25 to 30 per cent TiO_2, with some 15 to 18 per cent silica and lime, alumina and magnesia as bases, magnesia having been recognized by me as an essential constituent to insure the best running. These ores, being inaccessible to a railroad, had to be transported on corduroy roads to North Creek, where they could be loaded on cars. This brought their cost to $15 per ton delivered at Buffalo. This precluded the idea of making a test on a larger scale unless we could find a furnace of some ten tons capacity, which it proved impossible for us to do. Later on, within the last two years, Mr. Bachman melted similar titaniferous iron ores in one of the large blast furnaces of Weatherbee, Sherman & Co., at Porth Henry, making some 15,000 tons of a pig iron which he found of superior quality. In a very elaborate, comprehensive, scientific and technical report Mr. Bachman has given the fusibility and fluidity of the titaniferous slags run in the furnace, analyses of all materials and results of tests for strength as compared with that of the average pig irons made without titaniferous iron ores in the charges. His conclusions as a whole are a confirmation of my own as drawn from this run in Buffalo in 1894-95 in my small furnace. One of them particularly is worth mentioning, as I had come to the same conclusion in Buffalo. He says: "This run with titaniferous ores was made with an economy of fuel per ton of pig metal smelted," and yet one could read in technical publications in 1894 "that the smelting of titaniferous ores even if admissible meant such an excessive consumption of fuel per ton of iron that on this score alone they are unsuitable," leaving aside "titanium deposits in the furnace and pasty slags." This is an obvious contradiction, for if the furnace is "clogged up" by titanium which remains in the furnace, it does not go in the slag and the latter need not be pasty; or, if it goes in the slags, making them pasty, it does not remain in the furnace as titanium deposit. These titaniferous ores of the Adirondacks are magnetic, associated with ilmenite ($FeTiO_3$), an iron titanate, just as iron silicate ($FeSiO_3$) is found in certain ores (ferruginous peridotite). They are, like almost all titaniferous ores, low in phosphorus and sulphur, some as low as 0.017 per cent P and 0.02 per cent S, with 55 to 56 per cent metallic iron and 1.50 to 2 per cent SiO_2. The iron smelted from them makes an ideal open-hearth steel, and in our day open-hearth steel has superseded Bessemer steel.

Tests made by me, and in many foundries, of such pig metal added to ordinary pig iron in certain proportions has shown an increase of strength "over cast iron not treated of 29½ per cent in tests made and reported by Wm. Cramp & Co. and an increase of 4 per cent over cast iron treated with nickel."

If the results of such work as I have done, confirmed by the very recent blast-furnace runs on a large scale made by Mr. Bachman, will call the attention of metallurgists to these much abused ores, I will not have worked in vain.

Pioneer Work with Titanium as a Ferro-Alloy

But whatever value these ores may have, alone or in mixture with other ores as blast-furnace stock, their use for making alloys of iron or copper with titanium for the treatment of cast iron, steel, copper or copper alloys has opened a new and more important field of application in metallurgy.

Checked by the difficulties encountered in my efforts to secure such quantities of ore as are required for blast furnaces of our present size and capacity, I proposed to Mr. MacNaughton in 1900 to make a concentrate of titanium which, added to ordinary cast iron

or steel, would be likely to secure for the metal baths thus treated the same beneficial effect which tests had shown in pig metal smelted from these ores.

I may say here that Mr. MacNaughton was the one who supported me in these times of trial by his implicit confidence in me and the possibilities of my work.

About 1900 I started making ferro-titanium at the old Porter house in Niagara Falls by reducing titaniferous iron ores in an electric arc furnace. I used preferably those ores containing the highest percentages of TiO_2, such as ilmenite containing 40 per cent TiO_2 and 50 per cent more or less oxide of iron, or even rutile containing 93 to 95 per cent TiO_2. The furnace, being made of a masonry of graphitic material, formed the cathode and a carbon electrode, which was movable vertically by means of a mechanical device, or automatically by the current itself, formed the anode. A properly comminuted mixture of the titaniferous material and of the carbon required for reduction of both TiO_2 and oxide of iron was charged gradually into the furnace as the current was turned on. Whenever the relative proportion of TiO_2 and oxide of iron were such as to produce an alloy higher in titanium than was desired, some scrap iron was charged with the mixture to dilute the alloy, so to speak. In this manner I made alloys containing from 10 per cent to 25 per cent or more, but practice in steel and other works has shown that an alloy containing some 15 per cent of titanium was best suited for most purposes.

Whenever the presence of carbon in the ferro-carbon-titanium was considered objectionable for special applications, I reduced the titaniferous materials by my aluminium-bath process. Instead of using a mixture of finely powdered aluminium and titaniferous material, as in Goldschmidt's thermit process, the aluminium I used for the reduction of the oxides was melted in the electric furnace and the titaniferous materials charged directly into the bath. In such cases I used preferably TiO_2 as rutile in order to avoid using the aluminium which would have been required for the reduction of the oxide of iron of the ore, charging scrap iron with the rutile to dilute the alloy to the desired content of titanium. In this manner I made ferro-titanium practically free from carbon, containing only from 0.18 to 0.50 carbon, and by reducing the amount of scrap iron added I was able to make ferro-titanium as high as 80 to 85 per cent titanium.

Titanium as a metal is as white and as shining as silver, but very hard and brittle, so that it has no particular use as such. Alloys high in titanium, such as 75 to 85 per cent, and even those with less tenure in titanium, are also white like silver and scratch glass and even quartz deeply.

This aluminium bath process is of more general application. Thus if a tungstic ore containing oxide of iron is charged, a ferro-tungsten is obtained free from carbon. I have made thus 85 per cent tungsten alloy. By using manganiferous ores I was able to make in the electric furnace 85 to 88 per cent ferro-manganese free from carbon, and by using chromic iron, a ferro-chrome of about 80 per cent chromium free from carbon.

Effect of Titanium in Steel

By adding to a bath of steel or to cast iron a ferro-carbon-titanium containing some 15 per cent of titanium, the bath of metal was cleansed from dissolved or occluded gases, such as oxygen and nitrogen, and from oxides of iron generally present in steel, specially in Bessemer steel. When air is blown through the molten pig iron the titanium of the alloy combines with oxygen as TiO_2; with nitrogen as titanium nitride. The oxide of iron is reduced to iron by the titanium and the carbon of the alloy, the titanium combining with its oxygen to form TiO_2. The slag, always present in metallic bath, rises and carries with it the titanic dioxide and the titanium nitride to the top of the ingot or ladle. The TiO_2 entering the slag renders it more fluid and fusible, as proved by experiments I have carried on for Dr. P. H. Dudley, the expert of the N. Y. C. R. R. A slag collected by him at the top of an ingot and containing 6½ per cent of TiO_2 had a melting point of 1290 deg. C., lower than or about the same as that of an ordinary blast-furnace slag. By adding enough TiO_2 to such a slag to have in it some 13 per cent TiO_2, its melting point was lowered to 1190 deg. C., as determined by Mr. Fitz Gerald.

The presence of titanium in steel to the extent of 1 per cent or more imparts to the steel certain very special properties to which, later on, I may have occasion to direct your attention. The head of a crucible-steel ingot treated with titanium cast in 1900 at Atha & Illingworth, East Newark, had five holes drilled in it to obtain specimens for analysis. These holes are as bright now as they were when first drilled, though exposed to the air in my office. This ingot contains 1.10 to 1 per cent titanium, and the steel was so hard that it was drilled with difficulty.

Copper, as is well known, absorbs when melted, a large amount of gases, and the bath contains oxide of copper. For the treatment of copper and its alloys, such as bronze, brass, manganese or aluminium bronze, I have made a copper-titanium containing any amount of titanium, though 10 to 15 per cent appears better adapted as a scavenger of the copper bath. I have also made aluminium-titanium containing 45 per cent titanium for seasoning aluminium bronzes. They are made in the same manner as ferro-carbon-titanium or ferro-titanium in the electric furnace. For copper-titanium, TiO_2 and aluminium are charged in the furnace in a bath of copper. For aluminium titanium, the TiO_2 is charged directly in the bath of aluminium. The reaction of aluminium on oxides being exothermic, much less current is required for the reduction proper.

As is well known, the affinity of titanium for O and N is such that the metal burns at 800 deg. C. or thereabout in an atmosphere of these gases. (Wöhler and St. Claire Deville). It is so strong that when large cakes of alloy free from carbon are broken while hot the section exposed to the air colors itself with fine iridescence, presenting all the colors of the rainbow: blue (probable TiO), gold (probably nitride), copper (probably cyanonitride formed by the small amount of carbon still present), and combinations of these.

I have experimented with ores containing 1.50 to 2 per cent of phosphorus, adding even apatite (lime phosphate) to the mixture, so as to obtain a pig iron as high in phosphorus as I could. Contrary to what might have been expected, the pig metal containing 0.40 titanium and from 2.50 to 3.50 per cent phosphorus had the strength of fair No. 1 or No. 2 pig iron. This suggested treating phosphoric pig metal, generally weak and close grained, with ferro-titanium, so as to incor-

porate a divided amount of titanium in it. The results were very encouraging and were presented by me at the Pittsburgh meeting of the A. I. M. E. in 1896.

I have also experimented with the smelting of titaniferous ores in mixture with manganiferous ores, even in a coke furnace. I was able to introduce some 3 per cent to 3.50 per cent of titanium in cast iron, and by addition of MnO_2 the pig iron contained 2 to 3 per cent Mn. Manganese appears to cause the titanium to pass into the cast iron, as it alloys readily with titanium.

Other Titanium Compounds

If a ferro-titanium practically free from carbon, made by my aluminium bath method, preferably as high in titanium and low in iron as possible, is dissolved in hydrochloric acid, a fine violet solution is obtained—a ferrous titanium chloride. With this violet solution I have been able to bleach cotton, silk and wool. As is well known, silk and wool cannot be bleached in agents capable of generating free chlorine, which injures and attacks these fabrics. Still I was able to bleach completely some 2000 yards of such fabrics by digesting them in this diluted violet solution, boiling for a shorter or longer time, according to the intensity of the dye to be bleached or the yellowish tint of the white fabrics. Silk and wool, colored or yellowish, were thus bleached without injury to the fabrics. The double chloride contained about 40 to 50 per cent $TiCl_3$, titanous chloride, the balance ferrous chloride. During the operation, especially as the temperature reached near the boiling point, TiO_2 precipitated, thus showing clearly that the chlorine must have been set free and must have combined with the ferrous chloride to form ferric chloride, the chlorine generated acting in the nascent state without even coming as free chlorine in solution.

The fact that TiO_2 was precipitated from one of its compounds by organic matter suggested to me the possibilities of precipitating TiO_2 from others of its compounds by vegetal or animal organic matter. The results were very remarkable. If to a solution of titanic sulphate $Ti(SO_4)_2$ is added a water extract of organic vegetal or animal substance, and the liquid gently digested to boiling and boiled for a short time, TiO_2 is precipitated and, when calcined, is obtained as a soft, smooth, flourlike, pure white powder, requiring no mechanical pulverization. This is such a characteristic of the action of these organic substances that a number of them, such as water extracts obtained from dry leaves, green leaves, sawdust, tannin, wood pulp, woodpulp liquor, horse chestnuts, beans, docks, cranberries, radishes, etc., and urea itself, have given the same results. One of the interesting features of this process of obtaining TiO_2 pure white and smooth in impalpable powder is that if this same titanic sulphate solution be precipitated by NH_4OH or Na_2O, and boiled, the TiO_2 calcined is granular.

This method finds a direct application in the production of a white titanic pigment, a product which our company is to manufacture on a large scale. Calcined TiO_2 possesses a remarkable property of covering when used as paint material, alone or in mixture with such other pigments as are used in the trade for paints. Its superiority on this score, when prepared with proper oils, over white lead or white zinc is remarkable, and, besides, TiO_2 pigment is not attacked by gases.

Chemical Alliance to Meet

THE first annual meeting of the Chemical Alliance, Inc., will be held at the Hotel Biltmore, New York, on Wednesday, Feb. 6, at 9 a. m. As previously stated in our columns, the Chemical Alliance, Inc., has taken over the work of the Committee on Chemicals of the Council of National Defense, and has a permanent office at 540 Woodward Building, Washington, D. C. Membership in the alliance is open to all individuals, firms or corporations in the United States engaged in the chemical or allied industries. The annual dues are $25 with no entrance fee charged. Sections already organized include Acids; Coal Tar By-Products; Electrochemical; Fertilizers; Alkali, and others. The meeting on Feb. 6 will be open to qualified manufacturers whether or not they are yet members. A large attendance is anticipated.

American Dyestuff Industry Organizes

ALMOST important forward step was taken by American dyestuff manufacturers and allied interests when they formed a permanent organization at the Chemists' Club in New York on Jan. 22 and 23. Practically all of the important manufacturers and dealers were present and the interest shown and results accomplished speak well for the future of the industry in this country.

The meeting was called to order at 10.30 a. m. on Jan. 22 by H. Gardner McKerrow, the father of the movement to form a permanent organization. Frank Hemingway was chosen temporary chairman and made a short speech outlining his idea of what the aims of the organization should be. He laid especial emphasis on the value of meeting together socially and discussing each other's problems. He urged a quality membership and the formation of a committee of organization. C. D. Jenkinson of the National City Bank was chosen temporary treasurer and C. C. Bennett of the Color Trade Journal, temporary secretary.

The chairman then called on Mr. McKerrow to outline the objects of the convention. Mr. McKerrow mentioned some of the pressing problems confronting the dye industry, such as standardization, tariff, patent laws, arbitration of disputes, prevention of inferior exports, protection of contracts, etc. Others who spoke during the two days were Dr. J. Merritt Matthews, Dr. Wallace Pierce of the United States Conditioning and Testing Laboratories, who spoke on "Standardization," Mr. Bradford Webster, who spoke on "Arbitration," Mr. A. E. Parker, who spoke on "Patent Law," and Dr. Grinnell Jones, who told of the work the Tariff Commission is doing in regard to the dyestuffs tariff. Dr. Jones has been asked to make recommendations to the commission in about four weeks. A committee was appointed to confer with Dr. Jones.

On the first day of the meeting an organization committee was formed consisting of Messrs. L. A. Ault, J. Merritt Matthews, Mr. David, H. G. McKerrow, August Merz, Mr. Woodward and Mr. Hyndman. This committee will formulate recommendations for a name for the organization, by-laws, classes of membership, etc., and report at the Annual meeting to be held March 6 at the Chemists' Club.

The Physical Properties of Copper and the Factors by Which They Are Affected—I*

BY PAUL D. MERICA
Division of Metallurgy, U. S. Bureau of Standards

At no time in the history of the technology of metals, their production and manufacture, has the necessity for accurate information concerning their general physical properties been more keenly recognized in the industries than to-day. The day is not far past when the scientist, either chemist or physicist, in the manufacturing plant was considered a luxury, and qualitative or even comparative knowledge of the characteristics of materials was considered quite sufficient for every-day plant operation. With industry's tremendous growth and ramification, however, has come increased demands for performance upon the materials at its disposal, which has been possible of fulfillment only through more detailed and accurate study of the characteristics of these materials than was considered necessary before. Not only has it become necessary to study more thoroughly and quantitatively than before characteristics which already were utilized, but it has become necessary to pay attention to characteristics of materials which formerly were hardly considered of more than merely scientific interest. Thus have the thermo-electric properties of metals been of late the subject of quite intensive investigation.

This growing realization of the manufacturing industries, that increasingly they require accurate physical data on metals and alloys, has been borne in upon the writer by the numerous requests for such information which come to the Bureau of Standards, and so frequently has he had occasion to search the literature for accurate and dependable data concerning this or that characteristic of a metal or alloy in answer to their requests and for his own purposes, that he has often wished that such might have been grouped in one place, that it might be more generally and readily accessible to those for whom it is of interest.

In view of these demands therefore it seemed of sufficient importance that an attempt has been made, as a beginning, to assemble for the metal copper all of the most reputable physical data in the form of a sort of handbook of information, as well as to give the complete bibliography of the data for those who might wish to examine them critically. In this compilation the data and information have been put in the form of tables and curves, the latter being reproduced in such dimensions that accurate interpolation of values on them is possible by the use of a rule graduated in decimal parts of an inch. The probable degree of accuracy of data is indicated by the number of significant figures in the values given. The bibliography is given at the end and contains the sources to which the numbers refer.

The actual labor of assembling these data has been most amply repaid, the author feels, by the instructive facts which have thereby been brought to his attention.

In the first place it is most interesting to note the characteristics which have received the most attention and which have been quantitatively most accurately studied—characteristics, almost always, of technical and industrial significance, as for example, electrical conductivity, in the case of copper. Industry has been served by science as never before.

Another interesting fact is apparent in the study of such data, namely, the lack of recognition on the part of the scientist who has measured physical properties of the magnitude of the effect of the physical state and the chemical purity or composition upon these properties. The author has seen instances in which a property has been measured most carefully and by most elaborate apparatus, using a sample of material not physically or chemically sufficiently defined that an error of ten times the experimental error would have been of significance. It has remained for the experience of the manufacturer and producer of metals to guide the physicist in his physical studies of such material.

This article therefore attempts to consider the physical data of copper in relation to the chemical purity of the copper and to its physical state, by which these properties are often most markedly affected. There are several chapters which could be most satisfactorily elaborated if the experience of several manufacturers in copper were available, such as that for example on the defects or "disease" of copper, and that upon the effect of impurities on the properties of copper. It is to be regretted that information of this sort which is based upon day-by-day close observation of this metal and which is of such great technical significance should not be at least in large part the property of the technical world; if this article by its very incompleteness in those chapters induces a change in the attitude of those having such private store of information, it will have most amply served its purpose.

METALLOGRAPHY OF COPPER

The purest copper produced commercially, that which has been electro-deposited and not remelted, or has been remelted *in vacuo*, consists structurally of an aggregate of copper grains or crystals, the latter belonging to the regular or cubic system. Photomicrographs, Figs. 1 and 2, show pure electrolytic copper as deposited in the form of cathode strip, not remelted. Figs. 3 and 4 show copper as deposited in the form of electrotypes (38), and show the twinning in the columnar crystals and the etching pits inside of the grains.

When copper is remelted, it takes up oxygen, only part of which is removed by poling, such that about 0.05 per cent remains in the ingots cast from the fur-

*Extract from forthcoming Bureau of Standards' circular on copper

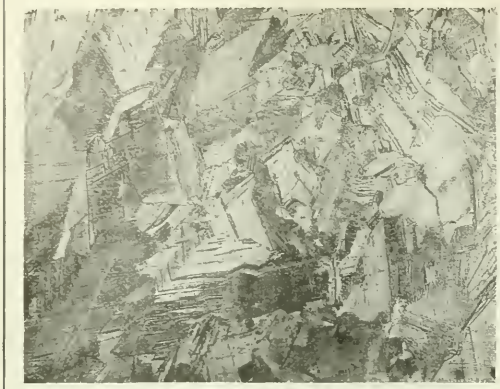


FIG. 1. CATHODE COPPER. × 100

FIG. 2. CATHODE COPPER. × 100

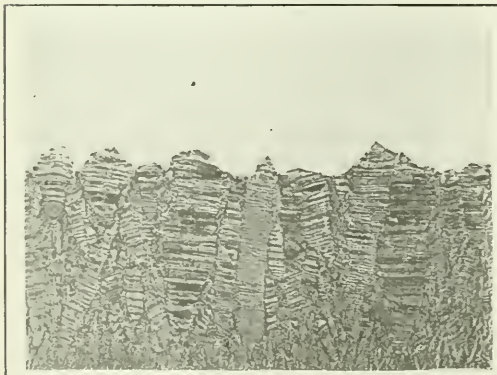


FIG. 3. ELECTROTYPE COPPER. × 300

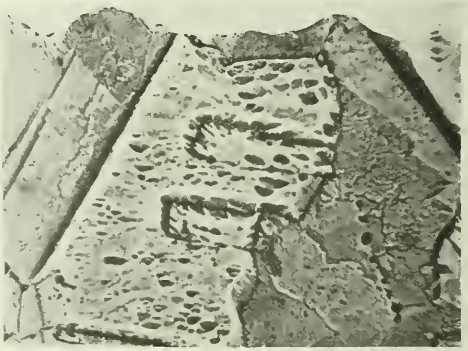


FIG. 4. ELECTROTYPE COPPER. × 500

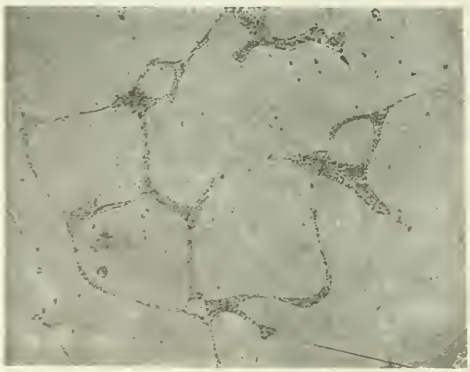


FIG. 5. CAST COPPER CONTAINING ABOUT 0.05 PER CENT OXYGEN. ×100

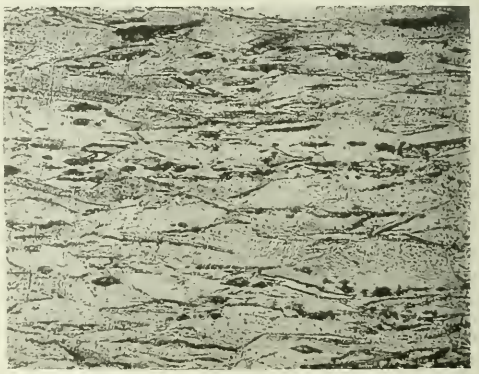


FIG. 6. HARD-DRAWN TROLLEY WIRE, 23/64 IN. × 250

nace. The appearance of such cast copper is shown in Fig. 5. The oyxgen is present as Cu_2O, which forms a eutectic with copper of the composition 3.45 per cent Cu_2O, melting at 1063 deg. C.; it is not appreciably soluble in solid copper. It presents under the microscope a bluish-gray appearance with a characteristic

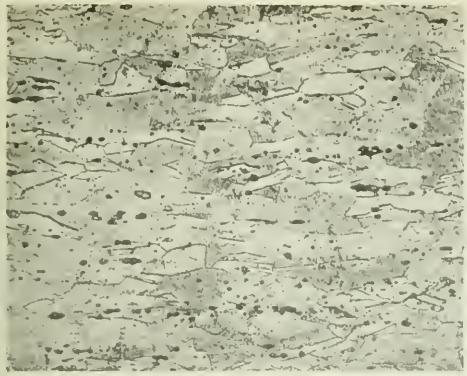


FIG. 7. MEDIUM-DRAWN WIRE, 7 64 IN. × 250

FIG. 8. SOFT WIRE, $\frac{1}{4}$ IN. × 250

red "glow" at the center of each particle, and cannot be confused with other inclusions in copper. The Cu_2O content of cast copper may be readily determined planimetrically from photomicrographs or on microscope ground glass (33).

The structure of such cast copper is broken up by the mechanical and heat treatment it receives in the mill, and it recrystallizes, appearing as shown in Figs. 6, 7, 8 and 9, illustrating different forms of commercial copper. The oxide is present in rows of fine globules, parallel to the axis of forging or working.

In the hard-drawn copper (Fig. 6) the grains are crossed by numerous etch-bands, perpendicular to the direction of drawing, and characteristic of hard copper; the grains are also elongated in the same direction. This is true also, but in less degree, of the medium-drawn wire, Fig. 7. When hard-drawn copper is annealed it recrystallizes; fine grains make their appearance within the larger original strained grains and generally at the border of the grains or along twinning planes and grow. The recrystallization takes place simultaneously with the softening of the metal; the temperature ranges of recrystallization coincide with those of the annealing softening (see Fig. 19), *i. e.*, from 250 deg. to 400 deg. C. After a full anneal the metal assumes the structural appearance shown in Fig. 8.

Figs. 9 and 10 show the appearance of hot-rolled copper plate or sheet, $\frac{1}{4}$ in. thick.

The grain size of copper may vary within wide limits. When just recrystallized, after cold-drawing or rolling, the grains will have diameters of from 0.0005 to 0.003 in. approximately, whereas after annealing at higher temperatures the diameters may go up to from .005 to .015 in. The grain size depends upon the extent of the reduction and of the annealing; this in commercial practice depends on the size of specimen, so that one may find in hard-drawn heavy sections a grain size larger than in soft smaller sections. The presence of oxide particles has been shown to hinder grain growth, in preventing coalescence of the adjoining grains.

Besides Cu_2O, bismuth and lead, when present in copper, are present at least except in quite small amounts (see below) as discreet particles, visible under the microscope. Other impurities, silver, gold, nickel, manganese, arsenic, antimony, zinc, phosphorus, etc., dissolve to a greater or less extent in the solid copper and leave no microscopic trace of their presence, except pos-

FIG. 9. HOT-ROLLED $\frac{1}{4}$-IN. SHEET. × 100

FIG. 10. GASSED COPPER—CRACKS. × 100

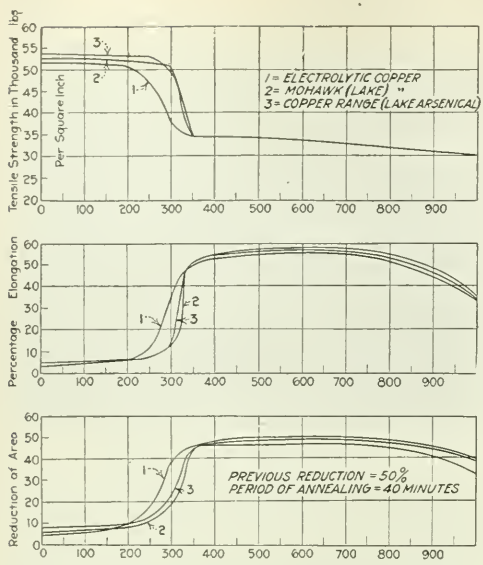

Tensile Strength in Thousand lbs Per Square Inch
1= ELECTROLYTIC COPPER
2= MOHAWK (LAKE) "
3= COPPER RANGE (LAKE ARSENICAL)
Percentage Elongation
Reduction of Area
PREVIOUS REDUCTION = 50%
PERIOD OF ANNEALING = 40 MINUTES

FIG. 19. EFFECT OF ANNEALING ON MECHANICAL PROPERTIES (TENSILE TEST) OF COMMERCIAL VARIETIES OF COPPER (191)

	% Oxygen	% Arsenic + Antimony	% Silver
Curve 1. Electrolytic copper	.071	.000	.0005
Curve 2. Mohawk copper (Lake)..	.052	.096	.069
Curve 3. Copper Range copper (Lake arsenical)	.055	.296	..052

Previous reduction 50%.

sibly in the cast state, when their presence gives a cored or dendritic structure to the metal.

Copper is best etched for microscopic examination with ammonium hydroxide, with ammonium persulphate solution or with a combination of the two; hydrogen peroxide may be used with ammonium hydroxide in place of ammonium persulphate.

Bragg (35) has shown by his method of X-ray examination that the copper atoms in crystalline copper are arranged in a face-centered cubic lattice; there is therefore apparently no copper molecule in solid copper smaller in size than the grain itself.

1. Possible Allotropy; Transformation

It is generally assumed that copper does not exist in any allotropic forms, but that the form which is stable at ordinary temperature persists also at lower and higher temperatures. Thermal analysis and microscopic examination disclose no evidence of any chemical transformation of any sort.

Cohen and his co-workers (42, 43) from measurements and consideration of the thermal expansion and electrical resistance, believed that they had discovered in electrolytic copper a transformation point at about 70 deg. C. The very careful electrical resistivity measurements of Burgess and Kellberg (41) do not however indicate any such point; the electrical resistivity varies almost linearly in a smooth curve between 61 deg. and 74 deg. C. The results of Cohen are possibly to be attributed to the presence of Cu_2O in the copper tested or to the fact that the chips or wire used were in a state of initial stress or of unstable (fine) crystal structure.

Schützenberger's (45) allotropic copper has been shown by Benedicks to owe its properties to inclusions of Cu_2O and acetate of copper. It is harder and more brittle than copper and is made by the electrolysis of slightly alkaline solutions of copper acetate.

CHEMICAL PROPERTIES

Copper is not oxidized in dry air at ordinary temperature nor in moist air in the absence of CO_2. In dry air the oxidation at temperatures under 180 deg. C. is insignificant; above that temperature are formed CuO and Cu_2O. It is not readily attacked at temperatures below the melting point by H_2, N_2, CO, CO_2 or H_2O. Elliott claims that superheated steam makes copper brittle. In the presence of NH_4OH copper is readily oxidized in air; this reaction is utilized as a method of ozone O_3 absorption.

Copper does not dissolve in the absence of air in dilute HCl or dilute H_2SO_4, but readily in HNO_3, and also in KCN. In the presence of air, dilute acids, including certain organic acids, attack it slowly; at higher temperatures concentrated H_2SO_4 attacks it, forming SO_2, $CuSO_4$, etc. It is also corroded slowly by saline solutions and sea water.

Foerster (3) discusses the anodic and cathodic electrochemical behavior of copper, characteristics of great importance to the electrolytic refining industry.

Heath (8) describes the methods in use for the analysis of copper and its alloys.

PHYSICAL PROPERTIES

1. Electrical, Magnetic

(*a*) *Electrical Conductivity.* — The International Electrotechnical Commission in 1913 adopted the present international standard value for the electrical resistivity of annealed copper; this is

0.15328 ohm (meter, gram) at 20 deg. C.
0.017241 ohm (meter, mm²) at 20 deg. C.
0.67879 microhm (cu. in.) at 20 deg. C.

This value is based upon the values obtained by the various national physical laboratories (49, 60) for ordinary high-grade commercial refined copper in the annealed state; it represents an average value for such materials. The standard density is 8.89 grams per cubic centimeter.

Investigation made at this bureau showed that for 89 annealed samples of the purest commercial copper from fourteen refiners the mean value of the resistivity was 0.15292 ohms (meter, gram), the average deviation from this value being 0.26 per cent, the maximum, 1.7 per cent. It is thus seen that even in the purest grades of copper the variation in purity and physical state are sufficient to cause variations in resistivity of annealed samples of about ± 1.5 per cent. Some of the highest values found for the per cent conductivity of copper are the following:

Resistivity = 0.15045 ohms (meter, gram) at 20 deg. C. (annealed wire).
Per cent conductivity = 101.88 per cent.
Resistivity = 0.15386 ohms (meter, gram) at 20 deg. C. (hard-drawn wire).
Per cent conductivity = 99.62 per cent.

The first value (60) is for an annealed wire drawn

directly from a mass of native lake copper which had never been melted. The second value is for a hard-drawn sample drawn directly from a cathode plate without remelting. The average difference between the conductivity of hard-drawn and of annealed copper is 2.7 per cent.

It may be noted that in the investigation by this bureau of about ninety samples of commercial pure copper, the electrolytic samples, annealed, gave a mean value of 100.3 per cent, the lake samples, one of 100.02 per cent conductivity. The electrolytic samples also averaged about 0.40 per cent higher than the lake samples in the hard-drawn condition. According to Mr. Bassett, Technical Superintendent and Metallurgist, American Brass Co., "it is not uncommon to find a conductivity in commercial wire bars of 101.3 per cent to 101.6 per cent when soft-annealed."

It may be noted that the electrical conductivity, as also its temperature coefficient, afford very sensitive criteria of the purity of copper, and are most convenient

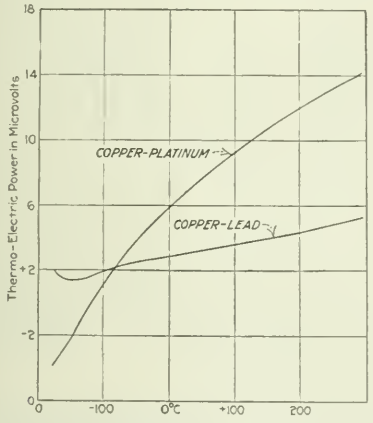


FIG. 11. THERMO-ELECTRIC POWER OF COPPER TO PLATINUM AND TO LEAD. (ADAMS)

when the metal is to be tested in the form of wire or rod.

Within the temperature limits 10 deg. to 100 deg. C. the conductivity of copper is a linear function of the temperature (within 0.2 per cent) (50), and the temperature coefficient of resistance is proportional to the conductivity; e. g.

$$\alpha\ 20^\circ = 0.0000393 \times \text{per cent conductivity.}$$

Thus as a consequence of this relation the change in resistivity per degree centigrade is a constant for copper, independent of the temperature (10 deg.-100 deg. C.) and of the purity, and is equal to 0.000597 ohm (meter, gram, deg. C.).

(*b*) *Thermo-Electromotive Force, Peltier Effect, Thomson Effect.*—In. Fig. 11 are given the curves of the thermo-electric power (dE/dt) of commercially pure copper to pure lead and platinum as determined by Dr. Adams (61), of the Geophysical Laboratory of the Carnegie Institution. According to him the thermal emf. of different samples of commercial copper wire to lead or platinum does not vary by more than 5 microvolts at 200 deg. C., showing a remarkable homogeneity of this metal in its commercial form. From these curves cubic equations have been derived as follows:

$$\text{(Cu-Pt)}\ \frac{\delta E}{\delta t} = 5.85 + 0.0406t - 7.46 \times 10^{-5}t^2 + 1.096 \times 10^{-7}t^3$$

$$\text{(Cu-Pb)}\ \frac{\delta E}{\delta t} = 2.84 - 0.0082 - 0.84 \times 10^{-5}t^2 + 0.226 \times 10^{-7}t^3$$

The thermal emf.'s are obtained by integration as follows:

$$E'_0 = \int_0^t \frac{\delta E}{\delta t}\ dt$$

$$\text{(Cu-Pt)}\ E'_0 = 5.85 + 0.0203t^2 - 2.48 \times 10^{-5}t^3 + 0.274 \times 10^{-7}t^4$$

$$\text{(Cu-Pb)}\ E'_0 = 2.84 + 0.0041t^2 - 0.28 \times 10^{-5}t^3 + 0.0565 \times 10^{-7}t^4$$

The emf. of copper to lead was calculated from the direct data of Adams on the emf. of copper-lead and of lead-platinum.

Adams and Johnston (62) give a general equation for the copper constantan couple, to be used in connection with deviation curves given by Sosman (66). The equation is:

$$E = 38.105t + 0.04442t^2 - 0.00002856t^3$$

The Peltier and Thomson effects may be calculated from the above equations.

(*c*) *Electrolytic Solution Potential.*—The electrolytic solution potential of copper to a solution containing its (bivalent) ions is given by Neuman (74), who found for

Cu NCuSo$_4$(18 deg. C.) normal hydrogen electrode: $E_h =$

-0.308(Cu ion concentration $= 0.11\ N$)

E_h calculated $=$

-0.329(Cu ions in CuSO$_4$ solution of N concentration)

Labendzinski (73) has determined with care the emf. of copper to its cupric salts. His results are as follows:

	Normality	E_h
Cu/CuSO$_4$	1.0	+ 0.304
	0.1	.284
	0.01	.262
Cu Cu $(NO_3)_2$	1.0	.331
	0.1	.294
	0.01	.266
Cu Cu (acetate)	Saturated	.278
	0.1	.264
	0.01	.242

Cohen (69) has shown that the emf. of copper amalgams of mercury content of from 1 to 16 per cent to a saturated solution of CuSO$_4$ at 25 deg. C. to Hg$_2$SO$_4$, Hg is 0.3471 volts.

The emf. of copper to solutions containing cuprous ions has been studied by Bodländer-Storbeck (71). They find that for Cu 0.05 NKCl + saturated CuCl:

$$E_h = -0.194 \text{ volts}$$

The emf. of copper to solutions of its salts (cupric) become less negative with increase of temperature (72). The temperature coefficient of emf. between 0 deg.-50 deg. C. is

$$\alpha = 0.00066 \text{ volts per degree C.}$$

(*d*) *Magnetic Properties.*—Pure copper is diamagnetic. Its magnetic behavior is very profoundly altered by slight traces of iron present as an impurity. Thus as little at 0.04 per cent of iron makes copper paramagnetic (75, 77). Values given for K, the susceptibility, are

$K_l = -0.66 \times 10^{-6}$ (79)

$= -0.82 \times 10^{-6}$ (electrolytic copper) (78)

$K_m = -1.22 \times 10^{-6}$ (native copper) (76)

$= -0.086 \times 10^{-6}$ (electrolytic copper; Fe = 0.008 per cent) (80)

$= -0.085 \times 10^{-6}$ (electrolytic copper; Fe = 0.0004 per cent) (81)

The value of K may thus be taken as -0.085×10^{-6} for pure copper. The temperature coefficient of K is given by the equation (78).

$$\alpha_0 = -0.0015$$

that is, the value of K decreases with increase of temperature.

Cu_2O and CuO have been found to be paramagnetic. (75)

$$K_{(CuO)} = \text{about} + 20.0 \times 10^{-6}$$
$$K_{(Cu_2O)} = +0.62 \times 10^{-6}$$

2. THERMAL AND OPTICAL

(*a*) *Melting Point, Heat of Fusion, Boiling Point, Vapor Pressure.*—The *melting point* of copper is taken as 1083.0 deg. C., the value adopted by the Bureau (87) in standardization of pyrometers, etc. Small amounts of oxygen lower the melting point markedly; the melting point of the eutectic Cu-Cu_2O (3.45 per cent Cu_2O = 0.395 per cent oxygen) being about 1063 deg. C.

Richards-Frazier (105) give 43.3 calories as the *heat of fusion* of copper.

It has not been possible to determine the *boiling point* of copper accurately; this has been due largely to the experimental difficulties. Greenwood (83, 84) states that there is an interval of about 100 deg. C. between the temperature at which copper first begins to form bubbles and that temperature at which ebullition is vigorous. This latter temperature he gives as 2310 deg. C. at 760-mm. pressure, as measured with a Wanner optical pyrometer on electrolytic copper in an atmosphere of hydrogen, and states that it can readily be duplicated.

V. Wartenberg (87) states that the boiling point of copper lies above 2200 deg. C., and Féry (82) places it at 2100 deg. C.

Greenwood (84) also made three determinations of the vapor pressure of copper, his values being:

at 2310 deg. C., 1.0 atmosphere
2180 deg. C., 0.34 atmosphere
1980 deg. C., 0.13 atmosphere

From these data Johnson (85) has given the formula

$$\log p = 9.14 - \frac{16{,}400}{T}$$

p = vapor pressure in mm. of mercury.
T = absolute temperature.

This gives a pressure of 0.001 mm. at 1080 deg. C. From this formula it follows (Johnson, *loc. cit.*) that the heat of vaporization of copper is about 75,000 calories.

(*b*) *Thermal Conductivity.*—An empirical law, approximate only, of Wiedemann-Franz-Lorenz connects the thermal conductivity of pure metals with the electrical conductivity by the following relation:

$$\frac{\text{Thermal conductivity}}{\text{electrical conductivity}} = K \times (\text{absolute temperature})$$

Determination of both conductivities was made in 1900 at the Physikalish-Technische Reichsanstalt (90) on a "pure copper" (traces of iron and zinc, together less than 0.05 per cent). The results were as follows:

Electrical resistivity (18 deg. C.) = 0.01782 ohms (meter, mm.^{2}), conductivity of 96.8 per cent (international standard)

Temperature coefficient of electrical resistivity at 18 deg. C. = 0.00393

Thermal conductivity (18 deg. C.) = 3.73 $\frac{\text{watt seconds}}{\text{cm. second. degree}}$

Temperature coefficient of thermal conductivity = 1.96×10^{-4}

$$\text{Ratio}\left(\frac{\text{thermal conductivity}}{\text{electrical conductivity}}\right) = 665 \times 10^{-8} \text{ (18 deg. C.)}$$

Temperature coefficient of this ratio = 3.67×10^{-3}

Schaufelberger (92) obtained in 1902 a value of 0.9382 $\frac{\text{Calorie}}{\text{second. gram. degree. centigrade}}$ for "pure copper." The electrical conductivity of this material is however only 92.8 per cent, showing the material to be inferior in purity to that used by Jaeger and Dieselhorst.

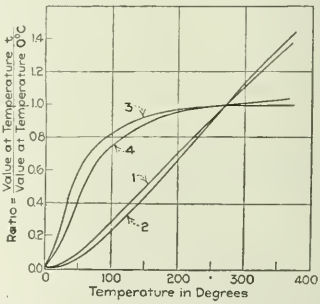


FIG. 12. THERMAL AND ELECTRICAL CONDUCTIVITY AT LOW AND HIGHER TEMPERATURE. (MEISSNER, 91)

Curve 1. $\lambda/\chi = \frac{\text{thermal}}{\text{electrical}}$ conductivity
Curve 2. $1/\chi$ = electrical resistivity.
Curve 3. $1/\lambda$ = thermal resistivity.
Curve 4. $\lambda/\chi T = \frac{\text{thermal conductivity.}}{\text{electrical conductivity} \times \text{abs. temperature.}}$
All quantities expressed as fraction of respective values at deg. C. The portion of curve between 0 deg. and 20 deg. abs. is extrapolated.

At lower temperatures, divergence from the Wiedemann-Franz-Lorenz law is still greater. The variation of the two conductivities and their ratio between 20 deg. and 400 deg. absolute is given by Meissner (91) in Fig. 12.

(*c*) *Thermal expansion.*—The linear thermal expansion of copper is not a linear function of the temperature but is well expressed (at least from —40 to +300 deg. C.) by a quadratic equation.

The thermal expansion of two samples of electrolytic copper furnished by the American Brass Co. has been determined at this bureau.

One sample was in the form of hot-rolled and cold-drawn trolley wire of N.E.C. copper wire-bar, of the following analysis:

	Per Cent		Per Cent
Copper	99.956	Nickel	.0001
Silver	.0005	Selenium	.0000
Iron	.0006	Tellurium	
Lead	.0007	Sulphur	.0017
Arsenic	.0025	Zinc	.0000
Antimony	.0011	Oxygen (diff.)	.0364

This sample showed between —24 deg. C. and +64 deg. C. a unit linear expansion, expressed (within 0.000003) by the following equation:

$$\frac{\Delta l}{l_0} = (16.48t + 0.00382t^2)\,10^{-6}$$

Another sample of electrolytic copper, battery assay 99.968 per cent Cu, hot-rolled, drawn and annealed, showed between — 49 deg. and + 305 deg. C. an expansion, expressed (within 0.000009) by the equation:

$$\frac{\Delta l}{l_0} = (16.34t + 0.00413t^2)\,10^{-6}$$

Dittenberger (95) gives the following equation for results determined between 0 deg. and 625 deg. C. on a sample of copper of "good conductivity":

$$\frac{\Delta l}{l_0} = (16.07t + 0.00403t^2)\,10^{-6}$$

Henning (96) has determined the expansion at low temperatures of the same material used by Dittenberger. He finds a contraction between 0 deg. C. and — 191 deg. C. of 2.917 mm. per 100 cm., which does not fit Dittenberger's formula.

Lindemann (97) finds Grüneisen's law, that the coefficient of thermal expansion / specific heat is a constant independent of the temperature, verified by determination

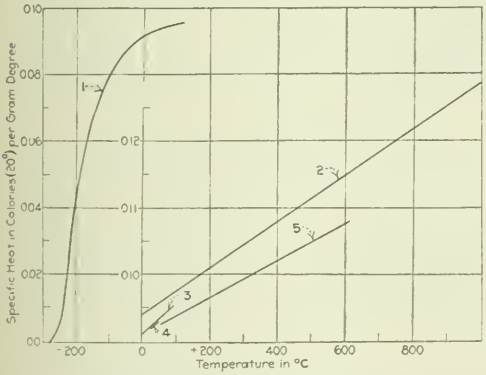


FIG. 13. EFFECT OF TEMPERATURE ON SPECIFIC HEAT (CONSTANT PRESSURE).

1. Nernst (102), electrolytic copper. Nernst & Lindemann (103) Keesom & Onnes (101).
2. Richards & Frazier (105).
3. Griffiths & Griffiths (99), electrolytic copper
4. D. R. Harper (100), electrolytic copper
5. Schübel (106).

of the expansion at low temperature. He finds

$\frac{1}{l}\frac{dl}{dt}$ from 85 deg. to 292 deg. (absolute) = 124 × 10^{-8}

20 deg. to 80 deg. (absolute) = 49 × 10^{-8}

80 deg. to 90 deg. (absolute) = 75 × 10^{-8}

(*d*) *Specific Heat.*—The specific heat of copper is *not constant* but varies with the temperature. In Fig. 13 are given curves taken from various observers indicating the effect of temperature on the specific heat.

The results of determinations made at the bureau (100) show that between 0 deg. and 50 deg. C. the specific heat of copper, 99.87 per cent pure, of 100.5 per cent electrical conductivity (Mattheissen Standard), is a linear function of the temperature, and may be represented by the formula

$$C = 0.0917 + 0.000048\,(t - 25) \text{ calorie 20 deg. / gram. degree}$$

This value agrees well with a probable value deducted from the results of many previous investigators.

Optical.—Copper is a metal, which takes a fairly high polish and reflects well. The reflecting power, the refractive and absorption indices are given by the curves

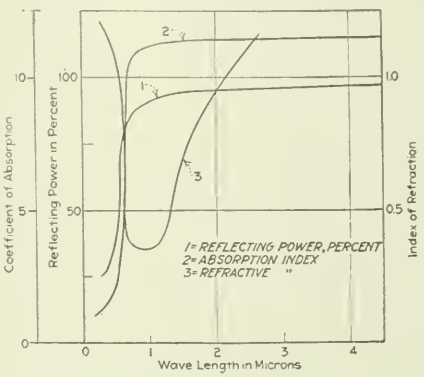


FIG. 14. OPTICAL CHARACTERISTICS OF COPPER

1. Reflecting power (perpendicular incidence) in per cent.
2. Absorptive index—K.
3. Refractive index—N.
Curve 1 from data by Hagen & Rubens (110, 111).
Curves 2 and 3 from data by Minor (113) and Ingersoll (112).

of Fig. 14. The selective absorption and reflection is strikingly indicated.

The relative emissivity of copper and of cuprous oxide at different temperatures as determined by various observers is given in Table I. The selective emissivity

TABLE I—RELATIVE EMISSIVITY OF COPPER

λ in Microns	1—Coefficient of Reflection. Hagen & Rubens (110, 111) 20° C		Relative Emissivity Stubbs (111)			Relative Emissivity. Tate (115) 20° C	Relative Emissivity of Cu_2O Burgess (108) 1160° C.
	Electrolytic Copper	Commercial Copper	1090° C	1127° C	1174° C		
450	512	63					
475			374	473			
500	467	56	374	381	402	51	68
550	405	52	344	340	349		
560						42	
600	185	28	210	210	197	29	
650	110	20	148	152	146		60
660						22	
700	09	17	106	130	124	21	

Temperature C	Relative Emissivity for λ = .65 Burgess & Waltenberg (109)	Relative Emissivity for λ = .55 Burgess & Waltenberg (109)	Relative Emissivity for λ = .66 Bidwell (107)
700			11
930	096		
1025	105		
1080	117		
1100	130		
1200			11
1400			11
1800			124

is clearly shown, the copper absorbing or emitting strongly at the blue end of the spectrum. According to Bidwell (107), Stubbs (114), and Burgess and Waltenberg there is no practical temperature variation of *Et* between 20 deg. and 1500 deg. C.

(*To be continued*)

Some General Aspects of Evaporation and Drying*

By HUGH K. MOORE

THE subject of Evaporation and Drying may be classified under six headings:

(1) Direct Evaporation or Single Effect (Pressure or Vacuum).

(2) Multiple Effect Evaporation.

(3) Air or Gas Drying.

(4) Radiant Heat Drying.

(5) Chemical Drying.

(6) Mechanical Drying.

The first is familiar to all of us, and is used, for instance, in boiling water in a teakettle or evaporating water as in the production of jelly or candy, etc., and is still done in the most primitive manner, namely, putting the substance into a sample shaped vessel and heating it by direct heat. In this we have the primitive steam boiler. The scope of this paper does not include either the history or the construction of the steam boiler, which was used as such by Hero, 150 B. C., for the production of power. We may, however, briefly consider the separation of two ingredients.

Direct Evaporation

Direct evaporation is used:

1. In cases where the amount of liquor is so small that it does not pay to have a multiple effect. An example of this is the evaporation of maple sap to make maple syrup, maple sugar, or candy, either under atmospheric pressure or vacuum.

2. In cases when the boiling points are so high that multiple-effect evaporation is not feasible; an example of this is the kettle process for caustic soda and caustic potash.

3. In cases where the liquor contains incrusting material, so that it is necessary to clean the tubes or pan very often. An example of this is the evaporation of salt brine containing calcium sulphate.

4. In cases where a certain sized crystal is desired. An example of this is the open drainer pan used in the salt industry.

5. In cases where the material to be evaporated is so corrosive that the materials required for the construction of the evaporator are too expensive to be used in anything but a single effect, of simple form. An example of this is to be found in the concentration of sulphuric acid, nitric acid, acetic acid, etc.

6. In cases where materials decompose at a high heat. Such an example is the production of concentrated coffee.

7. In cases where the object is to recover some volatile constituent. An example of this is the evaporation in the pot still. The evaporation in the column still is in this class, though it has certain features on the border line of the multiple effect.

8. In cases where the object is to obtain artificially a low temperature or a sudden chill. Both the absorption and compression systems of artificial refrigeration come in this class.

9. In cases either with or without vacuum, where the liquor to be evaporated is already a concentrated solution and its physical or chemical properties require that the final dried product be taken off as a film or powder or mass of crystals. Sulphite digester liquor is an example; this may be best handled in a rotary drum drier either with or without vacuum, according to the product one desires.

Direct evaporation in a vacuum is practised in nearly all the above cases, though not, as many persons seem to think, for economy of steam, but rather to secure the advantages of relatively low temperature. It is found that there is no great economy in direct evaporation under a vacuum over and above evaporation under atmospheric pressure, and none at all if the vacuum has to be produced by steam power.

Fig. 1 gives the values at different temperatures of the heat in a pound of water above 32 deg., the "latent" heat of vaporization, and the "total heat," or sum of the other two. Referring to Fig. 1, 1 lb. of steam at 212 deg. F. contains 1146 B.t.u. (above 32 deg.), while 1 lb. of steam at 134 deg., namely, under 25-in. vacuum, contains 1120 B.t.u. In other words, the pound of steam under 25-in. vacuum contains 97.73 per cent of the heat in a pound of steam at atmospheric pressure.

Multiple-Effect Evaporation

Multiple-effect evaporation is distinguished from single-effect in that the vapors evolved from a portion of the substance are condensed in a separated chamber by another portion of the substance, thereby giving up their latent heat to this other portion and liberating their equivalent in vapor from this other portion. Each such stage is called an effect. It will be seen that each effect acts simultaneously as a condenser and evaporator.

For instance, referring to Fig. 1, we find 1 lb. of steam at 242 deg. Fahr. contains 1161 B.t.u. in total heat, 950 B.t.u. in latent heat. Theoretically, if this steam heats water at 222 deg. Fahr., it should give up 971 B.t.u., evaporating thereby 1.007 lb. of water to steam at 222 deg. Fahr., having a total heat of 1154 B.t.u., and latent heat 964 B.t.u. per pound. This steam, in turn, could give an evaporation of 1.004 pounds of steam from water from and at 212 deg. Fahr. If we count also the available heat in the condensed water from the first effect we have 0.0103 lb. additional evaporation. In other words, in the double-effect operation as described we get 2.021 lb. of water separated from the liquor for 1 lb. of steam used. Now, the above figures are on a theoretical basis only. As a matter of actual practice, the evaporation in the above illustration would be a little lower, on account of the heat carried off in the drip, or condensed water, which would not be reduced quite to the temperature of the evaporated steam as was assumed in the illustration.

It will be seen that this operation can be repeated as many times as desired, provided only that a tempera-

*A paper read at the St. Louis meeting of the American Institute of Chemical Engineers, December 7, 1917.

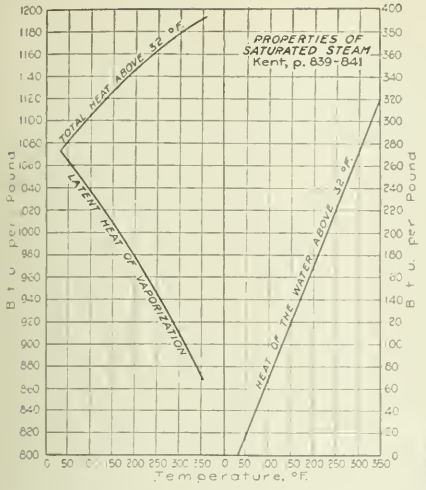

PROPERTIES OF SATURATED STEAM
Kent, p. 839-841
TOTAL HEAT ABOVE 32° F.
LATENT HEAT OF VAPORIZATION
HEAT OF THE WATER ABOVE 32° F.
B t u per Pound
Temperature, °F.

FIG. 1

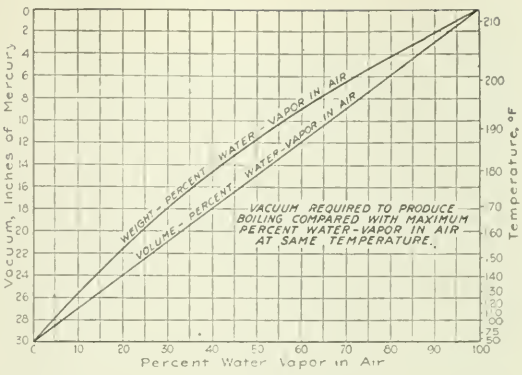

WEIGHT - PERCENT WATER - VAPOR IN AIR
VOLUME - PERCENT WATER-VAPOR IN AIR
VACUUM REQUIRED TO PRODUCE BOILING COMPARED WITH MAXIMUM PERCENT WATER-VAPOR IN AIR AT SAME TEMPERATURE.
Vacuum, Inches of Mercury
Temperature, °F
Percent Water Vapor in Air

FIG. 3

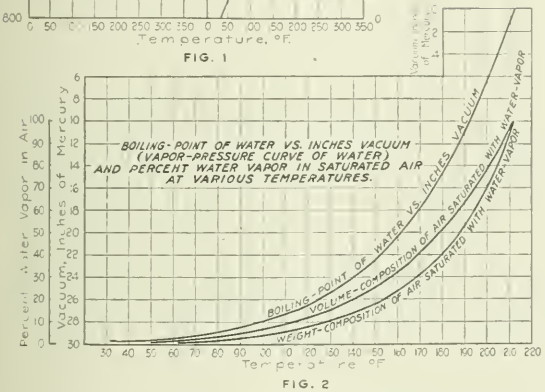

BOILING-POINT OF WATER VS. INCHES VACUUM (VAPOR-PRESSURE CURVE OF WATER) AND PERCENT WATER VAPOR IN SATURATED AIR AT VARIOUS TEMPERATURES.
BOILING-POINT OF WATER VS. INCHES VACUUM
VOLUME-COMPOSITION OF AIR SATURATED WITH WATER-VAPOR
WEIGHT-COMPOSITION OF AIR SATURATED WITH WATER-VAPOR
Percent Water Vapor in Air
Vacuum, Inches of Mercury
Temperature °F

FIG. 2

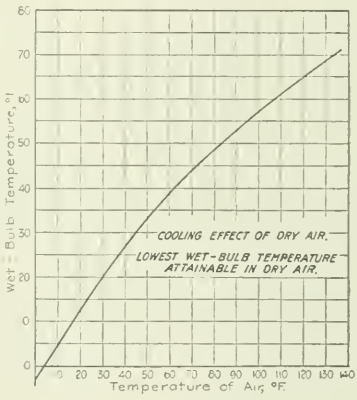


FIG. 4

ture difference is maintained between successive effects.

This, in brief, is the principle of multiple-effect evaporation. Later on in this paper the writer will explain a few of the intricacies of such evaporation.

The multiple-effect principle is used:

1. Where the amount of liquor to be evaporated is large.

2. Where the cost or concentration of the valuable ingredients is so small and the cost of fuel is so high that the evaporating cost is an appreciable item in the whole operation. As a matter of fact, multiple-effect evaporation is very seldom resorted to on a small scale, because the required constant attention of an expert evaporator man usually more than offsets the saving in fuel. Furthermore, the first cost of a small multiple-effect evaporator is all out of proportion to the work done.

Air Drying or Gas Drying

Air (or gas) drying is a method of evaporation in which the partial pressure of the vapor of the volatile constituent is kept less than the vapor pressure of the liquid by mixing with the vapor air, or other gas. In this case the pressure shown by a gage is the total pressure, or sum of the partial pressures of vapor and air.

Women know that they can dry clothes on a fine day even though the temperature be below freezing. They can also tell you that if the wind is blowing briskly the clothes will dry much more quickly. Here, then, you have a common case of air drying with which every one is familiar, though few could tell how it is possible. The curves on Figs. 2 and 3 show the vacuum required to produce boiling compared with maximum per cent water vapor in air at the same temperature. On this chart will also be found the relation to temperature. Thus, air at 187 deg. will take up additional water only if it contains less than 60 per cent by volume of water vapor, and water at 187 deg. boils only if a vacuum of 12 in. is exceeded. Then at 187 deg. air containing 60 per cent water vapor may be said to correspond to a 12-in. vacuum. At 195 deg., air containing 60 per cent *by weight* of water vapor corresponds to a 9-in. vacuum. Again, saturated air containing 10 per cent water by volume corresponds in temperature to 27 in. of vacuum (115 deg.). It will thus be seen that by decreasing the proportion of water vapor in the air the temperature effects of any desired vacuum can be obtained without the necessity of maintaining a real vacuum in a closed apparatus. A given volume of air, if maintained at a given temperature, can only evaporate a certain maximum amount of water (or other fluid), and this limit is only approached when the air has been brought into intimate contact with the substance to be evaporated,

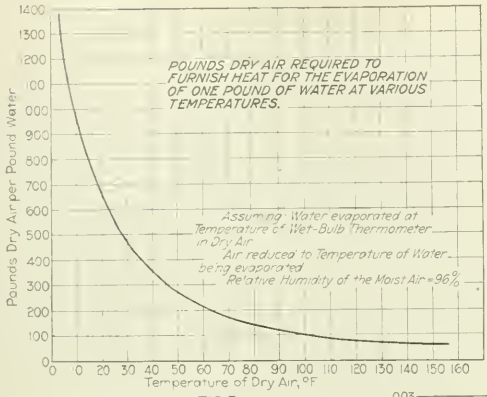

POUNDS DRY AIR REQUIRED TO FURNISH HEAT FOR THE EVAPORATION OF ONE POUND OF WATER AT VARIOUS TEMPERATURES.
Assuming Water evaporated at Temperature of Wet-Bulb Thermometer in Dry Air
Air reduced to Temperature of Water being evaporated
Relative Humidity of the Moist Air = 96%
Pounds Dry Air per Pound Water
Temperature of Dry Air, °F

FIG. 5

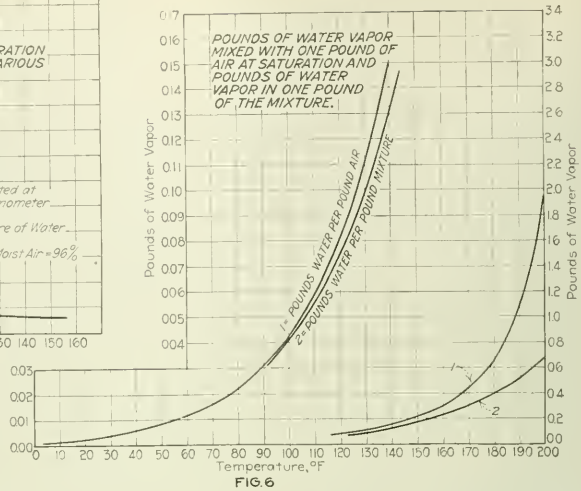

POUNDS OF WATER VAPOR MIXED WITH ONE POUND OF AIR AT SATURATION AND POUNDS OF WATER VAPOR IN ONE POUND OF THE MIXTURE.
1 = POUNDS WATER PER POUND AIR
2 = POUNDS WATER PER POUND MIXTURE
Pounds of Water Vapor
Temperature, °F

FIG. 6

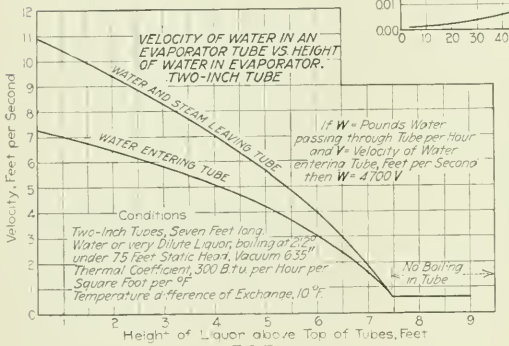

VELOCITY OF WATER IN AN EVAPORATOR TUBE VS HEIGHT OF WATER IN EVAPORATOR. TWO-INCH TUBE
WATER AND STEAM LEAVING TUBE
WATER ENTERING TUBE
If W = Pounds Water passing through Tube per Hour and V = Velocity of Water entering Tube, Feet per Second then W = 4700 V
Conditions
Two-Inch Tubes, Seven Feet long
Water or very Dilute Liquor, boiling at 212° under 7.5 Feet Static Head, Vacuum 6.35" Thermal Coefficient, 300 B.t.u. per Hour per Square Foot per °F
Temperature difference of Exchange, 10 °F.
No Boiling in Tube
Velocity, Feet per Second
Height of Liquor above Top of Tubes, Feet

FIG. 7

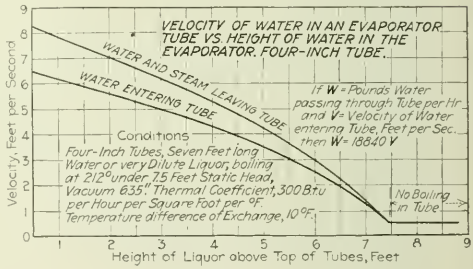

VELOCITY OF WATER IN AN EVAPORATOR TUBE VS. HEIGHT OF WATER IN THE EVAPORATOR. FOUR-INCH TUBE.
WATER AND STEAM LEAVING TUBE
WATER ENTERING TUBE
If W = Pounds Water passing through Tube per Hr. and V = Velocity of Water entering Tube, Feet per Sec. then W = 18840 V
Conditions
Four-Inch Tubes, Seven Feet long
Water or very Dilute Liquor, boiling at 212° under 7.5 Feet Static Head, Vacuum 6.35" Thermal Coefficient, 300 B.t.u. per Hour per Square Foot per °F
Temperature difference of Exchange, 10 °F.
No Boiling in Tube
Velocity, Feet per Second
Height of Liquor above Top of Tubes, Feet

FIG. 8

so that all parts become saturated. Of course, it goes without saying that the hotter the air and the drier the air the more rapid the evaporation. However, increasing the temperature of the air does not increase the temperature of the wet substance very greatly if the percentage of saturation is kept low enough. One pound of water requires about 1000 B.t.u. for its vaporization, whether it be evaporated under pressure or in a vacuum. Now, in every case the necessary heat must be supplied, either from the air, from the substance being evaporated, or by conduction to the substance being evaporated. It should be remembered that heat is relative, and things we consider cold may give up heat to things which are colder. It may be asked where the heat comes from that evaporates the water in clothes hung out to dry on a cold winter day, and what difference of temperature there could be. Perhaps this can be answered graphically by the curve of Fig. 4, which shows the cooling effect of dry air, based on wet and dry bulb-thermometer readings; also Fig. 5, showing pounds of dry air required to furnish heat to evaporate 1 lb. of water at various temperatures. Fig. 6 shows pounds of water per pound of air and pounds of water per pound of mixture when air is saturated at different temperatures. For example, Fig. 4 shows that with dry winter air at 30 deg. F., the clothes could drop to a temperature of 20 deg.. and Fig. 5 shows that 470 lb. of dry air at 30 deg. would contain enough available heat to evaporate 1 lb. of water at 20 deg. Fahr. This assumes that the air is originally dry, and leaves saturated. If, however, the air is not dry, and does not leave saturated, a greater quantity is required. It will be seen that in this case the air furnishes the requisite heat for the evaporation. As a brisk wind moves a greater quantity of air past the wet surface, it will readily be seen that the evaporation must necessarily be more rapid. The temperature of the wet clothes will depend on the saturation and temperature of the air, but cannot go below the values of Fig. 4. Here in a simple illustration are all the fundamental principles of air drying.

The writer has been asked why we cannot take a sufficient quantity of air and dispense with artificial heat. We can, but if it costs more for apparatus and power to move and utilize this air than it would cost to supply the required heat we have gained nothing, and perhaps have the additional expense of conditioning or filtering the larger quantity of air.

From the above it will be seen that while air drying at an elevated temperature partakes in some respects of the advantages of vacuum drying, it may not be as economical in the expenditure of heat, inasmuch as heat has to be supplied to raise the temperature of the air, as well as to furnish heat for the evaporation of water (or other fluid).

Having briefly touched on the principles of air drying, let us see under what conditions it may be profitably employed:

1. The drying, at relatively low temperature, of a substance which is continually entering and leaving the apparatus. In this case it would be practically impossible to obtain a vacuum. An example of this is the drying of pulp, paper, cloth, etc., over hot rolls. Heat is supplied to the rolls, and the hot, moist sheet, leaving the rolls, passes through the air and is dried. The rapid evaporation keeps the temperature down to such a limit that the pulp or paper is not seriously affected by the heat. Here, continuity of process and nature and amount of the materials are the controlling factors.

2. The drying, at low temperatures, of substances whose internal structure must be preserved. Examples are eggs, wood, pulp, pipe, etc. In the first example, for instance, if eggs were evaporated in a vacuum, one would have an edible product; but owing to the rapid evolution of steam from the interior as well as the surface, the organic structure would be so destroyed that one could not make an omelet from the resulting product; while if the eggs are air dried by letting this moisture gradually diffuse to the surface, the resulting product can be beaten up and a fine omelet can be obtained. The drying of wood in such a manner as to avoid checking is a more familiar illustration, and need not be gone into here.

3. Where the final product must be in a fine state of subdivision, and heating, even for a short time, may destroy some valuable characteristics.

An illustration is the evaporation of milk to milk powder and eggs to egg powder; these substances cannot be kept even momentarily at a high temperature during evaporation without altering or coagulating. Here the milk or eggs are reduced to such fine particles that they are nearly all surface. When these particles come in contact with hot, dry air they part rapidly with their water, and this rapid evaporation prevents their reaching too high a temperature.

Mr. O. G. Soule of Merrill-Soule has kindly furnished me with the following information as to the evaporation and drying of milk:

The milk is first condensed in a vacuum pan until it contains approximately 33 per cent solids. This is done for two reasons: First, it is a cheaper method of evaporation than evaporation entirely by spraying into the air; secondly, the resultant product, when finally dried, has what is called a greater apparent specific gravity; that is, the powder is more compact, and in an equal volume will have a greater weight than the product obtained entirely by the air spraying. After evaporation under vacuum to 36 per cent solids, the product is sprayed—under pressure of between 3000 and 4000 lb. to the square inch—through a minute orifice, with the result that the milk is subdivided into very fine spheres. This product is sprayed into a drying chamber through which is passed a current of air heated to approximately 180 deg. Fahr. The small particles of the liquid are thus entirely suspended in this current of air in the shape of minute spheres, representing an enormous surface, and resulting in very rapid evaporation. The product, as it dries, falls to the bottom of the drying chamber, or is carried along with the current of air and collected outside the drying chamber by means of a dust collector of special design. Since evaporation takes place in the air entirely, the particle being evaporated is kept cool during the evaporation; while if evaporation takes place in contact with a heated metal surface the product, during evaporation, is itself heated, and the albumin of the milk tends to coagulate. In the Merrill-Soule method of drying, this cooling effect is obtained, and the product does not become heated until the moisture is substantially removed. The advantage of this is apparent from the fact that neither the vitamines nor the enzymes are materially injured by this process; neither is the albumin coagulated. When the milk powder is reconstituted with water they find the original bacteria becoming active, the enzyme action apparently unchanged, and the growth-promoting qualities still in their original form. This, so far as they are aware, is a result unobtainable in any other way. While the milk powder is in its dry state there is found no material action taking place on account of the bacteria therein. The bacteria do not multiply, but rather tend to decrease in the product due to the absence of moisture. On the other hand, when moisture is put back into the powder the bacterial action goes on as in the original milk, and a similar fermentation takes place as takes place in milk.

A similar process is also applied to the drying of eggs; the egg albumin is not coagulated, and is soluble in cold water.

As a matter of commercial practice, milk is pasteurized before drying, thus killing pathogenic bacteria, and practically the only bacteria left in the powder are of the lactic acid variety, which are, of course, harmless or useful.

4. Drying such substances as are not affected by heat, but are either sticky or poor conductors of heat.

Such, for example, is the process used in drying salt, lime sludge, or the black liquor made by the soda and the so-called sulphate processes for wood pulp. In the latter case, water is not only evaporated, but the residue is also charred so that it loses its sticky qualities; but as the object is the recovery of the soda base, this does no harm.

Drying by Means of Radiant Heat

The writer discussed radiant-heat drying at considerable length in a previous paper before this society,* and so has no need to go into it here; neither is the time at his disposal sufficient to warrant its discussion at this time.

Suffice to say that probably in the near future it will be used in concentrating many substances which require a high temperature for evaporation and where there is no suitable material of which to construct the types of apparatus now in use. It is now used for the evaporation of the so-called sulphate black liquor. It is thought that this process offers a great opportunity to solve the difficulties encountered in connection with the phosphoric acids.

Chemical Drying

The ability of certain chemicals to absorb water or other fluids is made use of in drying many substances, and the principles are so well known to the chemical engineers that we can dismiss the subject by giving a few illustrations. These fall into a natural classification according as the wet material is a gas, a liquid, or a solid.

1. Undoubtedly the most use is made of this principle

*See this journal Aug. 1, 1917, p. 117.

in drying gases. Here we have two vapors mixed which it is desired to separate. This mixture of gases is passed through a chemical which absorbs one and allows the other to pass through unchanged. Thus in the hydrogenation of oil, dry hydrogen is required. In this case the wet hydrogen is passed through concentrated sulphuric acid, where the moisture is absorbed. Most wet gases attack pipes of the ordinary materials, but if they are dried few if any have any action whatsoever. Chlorine, sulphur dioxide, hydrochloric acid gas, hydrogen, and hydrogen sulphide are examples of gas which are handled in large quantities in this manner.

2. Liquids are sometimes dried in the same manner as gases. An emulsion of oil and water may be separated by hydrochloric-acid gas. Mineral oils are dried by the use of sulphuric acid, and in cases where a trace of acid must not be left they are dried by the use of calcium carbide. In either case the oil comes out more or less dry. Chloroform is dried over calcium chloride or zinc chloride, as well as sulphuric acid.

3. Solids may be dried either by contact with an appropriate gas or by immersing in a volatile liquid, which, uniting with the substance to be removed, will pass off easily at a much reduced temperature. As an illustration of the first method we may take the drying of crystallized magnesium chloride. In ordinary evaporation this would break up into magnesium oxide and hydrochloric acid, but if dry hydrochloric acid gas is passed through it under pressure the drying will be accomplished and the decomposition largely prevented. Or again, according to the second method, magnesium chloride may be dried to the decomposition point and then mixed with amyl alcohol and the mixture evaporated. In this case, very little decomposition takes place if the amyl alcohol is in sufficient excess and the operation is done in a vacuum.

Again, butter fats may be dissolved from their water and other admixture by dissolving in deodorized rhigolene or cymogene and evaporating the solvent at a low temperature.

Mechanical Drying

This hardly comes within the scope of this paper, and will be dismissed by classifying and giving a few illustrations. Five fairly common means might be distinguished: 1, squeezing; 2, filtering; 3, centrifugal force; 4, heating; 5, refrigerating.

1. The hydrostatic press may be used to dry wet materials, as, for instance, in pressing the water from wood pulp, oils and water from seeds, and water from fabrics. The compression of a saturated gas reduces its capacity to hold water vapor at the same temperature, and effects a partial drying.

2. Filtering may be illustrated by the separation of lime sludge from caustic liquor in a filter press.

3. The centrifugal machine in most cases is simply a filter in which centrifugal force is substituted for hydrostatic pressure, though in some cases the centrifugal force is so applied that it merely accelerates the natural separation of two materials of different specific gravities.

As a filter, the centrifugal machine is used most in separating crystals from a mother liquor. Thus: in separation of salt crystals from caustic solutions, or sugar from its mother liquor.

Centrifugals are used in the other manner in separating oil from water, or in separating an emulsion of cotton-seed oil, water and soaps of the fatty acids; or in separating the oil emulsions encountered in steam-power plants.

4. Air at its dew point may be dried in the physical sense by heating it. This is done in heating ventilation, etc. Of course, chemically there is just as much water in the air after heating as before heating, and this is only a case of apparent drying.

5. Conversely, air may be caused to give up its moisture by refrigerating. This principle is made use of in the dry-blast process in the production of iron and steel. Sometimes a gas may form a compound with water, or other substance to be removed, and may be used to dry itself. Thus, if liquid chlorine is sprayed through moist chlorine gas, or liquid sulphur dioxide through moist sulphur dioxide gas, the liquid will vaporize, abstracting heat from water and gas, and the water will be precipitated in solid form in more or less loose combination with the chlorine or sulphur dioxide, as the case may happen to be.

Heat Conductivity Data

The subject of evaporation and drying, in the sense as used by chemical engineers, is indissolubly connected with the subject of condensation and the heat conductivity of the materials used in the construction of apparatus.

The data used for conductivity through the metal partitions, which we are interested in when it comes to the designing of an evaporator, is not the thermal conductivity of metals, as given by physicists, as the conditions are not the same as those under which the physicists obtained their data. For instance, the heat conductivity of copper is given as 500, that of iron 233, and that of lead 103, all in B.t.u. per square foot per inch thickness per degree Fahrenheit difference per hour. Now, as a matter of fact, this data is of very little use, if any, to the engineer who has the problem of designing an evaporator for a liquid of given properties. If you have an evaporator with iron tubes, in which water and steam are the fluids on the two surfaces of the partition, you will get a conductivity of from 200 to 250 B.t.u. during the first stages of the heating; but during the second stage, that is, when ebullition becomes rapid, the conductivity increases to 1000. Now, the iron has not changed in the slightest degree, but the latter apparent conductivity is from four to five times as great, showing that we must look for some other factor than the conductivity of the metal alone. The factor in this case is the movement of the molecules of water. Water not in motion is a very poor conductor of heat, but when new molecules are brought in contact with the heated surface the absorption of heat from the heated surface is very much increased. Practically speaking, then, the large factor of conductivity in this case is not the metal but the rate at which heat is conducted from the surface of the metal to the liquid, and this factor may be expressed in terms of velocity of the liquid. The writer has obtained a conductivity of 1200 B.t.u. per square foot per degree Fahrenheit difference per hour through lead pipe by increasing the velocity of the liquid flowing through it. Under these same conditions, copper tube did not increase the conductivity more than could be accounted for by experimental error. Iron may have an apparent

conductivity of 200 to 250 B.t.u. to water not in motion, but if melted sulphur is substituted for the water the apparent conductivity drops to 3 B.t.u. A familiar case of the above is an ordinary boiler tube, which, having air on one side and water on the other, may not conduct more than 3 to 6 B.t.u. per degree difference Fahrenheit. Also a horizontal tube with water on the outside and steam on the inside will not have the apparent conductivity if it is 10 ft. long that it has if it is 3 ft. long. Here the determining factor is the length of the tube. As the steam condenses we have an accumulation of water on the bottom of the tube, and the depth of this increases as the length; since water itself is a poor conductor, and is not in this case in rapid circulation, it does not transmit heat readily to the tube. In the case of vertical tubes, in which the liquor is on the inside, there may be varying factors. The diameter may or may not be an influential factor. As you increase the length of the tube you tend to increase the velocity of the fluid inside the tube. This tendency to increase the velocity is due to the increase of the unbalanced pressure between relatively cool bodies of liquor in other parts of the bath and the warmer column of liquid and vapor circulating upward through the tube. This acts in much the same way as increasing the height of a chimney increases the velocity of the hot gases in the chimney. The effect of increased height may be offset, however, by an increase in the diameter of the tube, since in tubes of equal length the surface increases as the diameter, while the volume increases as the square of the diameter. It can readily be seen that the volume is so increased by increasing the diameter that the increase in heating surface is more than counterbalanced by the increase in weight of the liquor to be heated. See Fig. 7 and Fig. 8. This is what happens in the large central tube in some evaporators, or the outside zone in other evaporators, a downward instead of an upward current being maintained. An increase in the height of a tube may not always increase the heat conductivity. If the diameter be so small and the length so great that all the liquor entering it is transformed into steam, then an increase of height will be a detriment.

Brown Co., Berlin, N. H.

(To be continued)

Symposium on Potash

A joint meeting of the New York Sections of the American Institute of Mining Engineers and the American Electrochemical Society was held on Jan. 24, at which qualified speakers reviewed our various resources and gave the status of industries now contributing to our potash needs. The speakers and their topics were as follows: Col. Allerton S. Cushman, Frankford Arsenal, Philadelphia, and Alfred H. Cowles, Potash from Silicate Rocks; Dr. Wm. H. Ross, Department of Agriculture, Washington, Potash from Kelp; Leslie H. Webb, Western Precipitation Co., Philadelphia, Potash from Cement-Kiln and Blast-Furnace Dust; Sidney J. Jennings, Potash from Alunite; Kirby Thomas, Potash from Saline Lakes; E. G. Spillsbury, Potash from Greensand. Production from all sources in 1917 may amount to between 15,000 and 17,000 tons in terms of 80 per cent KCl. Cement-kiln dust is a promising source and may yield 70,000 tons per annum.

The Effect of the War on Engineering Education

By C. R. Mann

THREE years ago most of us thought that a world war could not last long because, however much kings and kaisers might wish to continue, the banker would stop it. But the financiers have not come up to our expectations in this matter, and we have therefore been compelled, unwillingly perhaps, to recognize that money is not the ultimate measure of national strength. National credit is the result and not the cause of intelligent industrial production; the engineer, not the banker, is the real power behind the throne.

This fundamental fact now seems so simple and self-evident that it is rather hard to remember the time when we thought otherwise. But though the rugged outlines of this fact are now sharply silhouetted against the ruddy dawn of the new age, the details of its meaning are but dimly discernible through the haze of speculation over the significance of the struggle. Naturally the engineer is intensely interested in the development of the details of the picture, for on him devolves the duty of interpreting the coming conceptions in terms of materials and organizations of men. And if education makes men, engineering education must be the first to feel the thrill of the dawning day.

Three elements in the picture can now be plainly perceived. These indicate that the engineer is from henceforth vitally involved in the control of credit, in the interpretation of the daily news, and in the organization of industry and commerce to make goods cheap and men dear.

In performing the first of these new functions, the engineer becomes the partner of the banker to determine which projects are worthy of financial support and which not. As the engineering spirit is more and more infused into this dispensing of credit, public service rather than excess profit becomes the inspiration for enterprise; intelligence in production becomes the best security for loans; ability to deliver the goods becomes the sure basis of financial success; and the control of tools gradually passes from the hands of those who own them legally into the hands of those who can use them effectively.

Newspapers and periodicals already sense the expansion of the engineering spirit in the struggle to make the nation strong. The distribution of wheat, the supply of sugar, the transportation of coal and the price of bread are now subjects which occupy an amount of space in the daily press that only a Thaw trial could formerly command. The public has never before realized how vital and how interesting factories, freight cars, warehouses, terminals, trucks and ships really are. Some faint conception of the necessity of organization for the common project of liberating life by winning the war seems to be taking shape; while an impelling desire to serve and to subordinate personal preferences to community interests appears to be dimly developing. These faint feelings of fraternity may grow into driving impulses, if editors continue to extol engineering enterprise rather than private profit in their interpretations of the daily news.

In many communities chambers of commerce or groups of engineers have organized to build up business

and boom the town. Through their efforts living conditions have been improved and many a city is being made a better place for homes. But the progress has always been hampered by the vested rights of individuals and of corporations, so that none has yet dared to envisage an entire community as a single working plant for the purpose of organizing it for the most intelligent production of human wealth. This can now be done. The war is opening many hitherto blind eyes to see that each gains more than he loses when he merges his strength with the might of all in an organization that is constructed for the purpose of releasing creative energy by giving each the work he is best qualified to do.

The time has come for such an organization in every community and every state, because the Federal Government is struggling to shape the nation into an organization of this type. Only so may the nation be strong; only so may communities add their utmost to the nation's strength. The responsibility for this work must finally be shouldered by engineers who are both masters of the mechanic arts and moulders of men.

For many years this country has been drifting toward the realization of these requirements. The war has but accelerated the process and precipitated conclusions that were bound to come, otherwise men trained by experience to meet the present crisis could not now be found. Continuity demands that the same conclusions remain valid long after the war is ended. Therefore, engineering schools will render service in proportion as they grasp the implications of these conclusions and express them in the work of instruction.

The possible conclusions for engineering education are many and complex; but two stand out in bold relief, namely, there must be closer co-operation between school and industry, and there must be more attention to the appraisement of values and costs.

The essential feature of the co-operation with industry is not the skill, the knowledge of workmen, or the feel of the machines which the student acquires from shop experience. Important as these are, they cannot compete with the spirit of investigation which must develop if the co-operation between school and industry is real and vital. There are thousands of unsolved problems in even such rough shop work as freshmen are permitted to do. The boy should be trained to discover these unsolved problems and to bring them back to school for discussion and solution. By making shop work in industrial plants the source of problems for solution in school, and by relating the class and the laboratory work in some degree to the problems raised, conditions most favorable to the self-development of the student may be realized. As he progresses, the problems become more and more intricate, until in his last year, if he has shown real engineering ability, he may be assigned as helper in industrial research, either at the plant or in the school laboratories. After such a training in defining and solving problems, closely co-ordinated with instruction in science and drill in mathematics, he should be able on graduation to take a responsible position without serving several years as an apprentice, as is usual at present.

To the faculty this type of co-operation with industry brings incentives for creative work in production and in education. For co-operation makes the school the source of solutions of industrial problems, not only with respect to the technique of manufacture, but also concerning the correlation of the community's productive processes with the training of its citizens as intelligent workers. Hitherto manufacturing companies have stood aloof and regarded one another with suspicion—and the Federal Trade Commission discovered that 200,000 of them are not paying expenses; but now they are ready to co-operate. Similarly in education, many manufacturers are supporting corporation schools to train their own help, while more than half the children in the entire country quit school at the sixth grade without being trained to earn a living, but they too are now ready to co-operate. If the men who are teaching in engineering schools rise to the responsibility and organize for the systematic study of community production, they could soon create a true university, with its feet firmly planted in industry and its soul consecrated to the task of utilizing science and literature to liberate the creative energies of men.

While close co-operation between school and industry gives that practical experience which is essential for mastery of the mechanic arts, it is not in itself sufficient to enable the schools to meet adequately the fundamental requirements of engineering in the new epoch. The Germans are technically well trained in the mechanic arts, yet they are but brutally strong. In order to strengthen the nation by infusing the engineering spirit in the control of credit, in the interpretation of the daily news and in the organization of industry for the production of human wealth, the engineer must have sound judgment in the appraisement of values and costs. This requires not only an understanding of finance and the meaning of money, but also a sympathetic appreciation of the things humanity holds to be most worth while. Even a practical project like building a bridge is ultimately controlled by some man's decision that the resulting value is worth the cost; and this decision is more difficult and subtle when it concerns profoundly the production of human wealth and the appraisement of human values and costs. The engineer is too often obliged to be only the employee of the bank, the corporation, or the state commission, because he believed that engineering is wholly a matter of technical skill; when control in this, as in everything else, is really vested in the decision of the question whether the game is worth the candle.

Training in the appraisement of values and costs does not require the addition of formal courses for that purpose, but rather the injection of this point of view into every branch of school work. For example, experiments in chemistry need not always be of the type: Analyze this baking powder. The project: Make baking powder and find out if it is cheaper and better than any you can buy, is vastly more effective as a training exercise. Presented as a personal effort to appraise the human values and costs in life's experiences, literature fascinates engineering students. Economics delight them when it is a critique of proposed solutions of the social problems defined by their daily co-operation with labor. Such exercises also foster the development of those homely virtues, which always make the working people the bulwark of a nation's strength—the sense of justice, feelings of neighborly kindliness, devotion to right, and respect for God and man.

Carnegie Foundation for the Advancement of Teaching,
New York, N. Y.

Recovery of Spelter and the Treatment of Retort Residues

By EDWARD MACKAY JOHNSON

Supt., Henryetta Plant, Eagle-Picher Lead Co.

IT IS customary at nearly all zinc smelters to make three draws of metal. The proportion drawn at each time is approximately as follows:

Smelting 50% Western Sulphide + 50% Leadville Calamine

	Charge	Blue Powder	Total
1st draw	22.7%	15.1%	37.8%
2d Draw	36.5	18.6	55.1
3d Draw	0.6	6.5	7.1
	59.8	40.2	100.0

Smelting Concentrates from Colorado Ore

	Charge	Blue Powder	Total
1st Draw	27.6%	10.2%	37.8%
2d Draw	35.2	15.0	50.2
3d Draw	5.0	7.0	12.0
	67.8	32.2	100.0

Smelting ⅔ Joplin Ore + ⅓ Leadville Calamine

	Charge	Blue Powder	Total
1st Draw	27.4%	10.8%	38.2%
2d Draw	34.4	14.5	48.9
3d Draw	6.3	6.6	12.9
	68.1	31.9	100.0

Smelting Straight Joplin Ore, Making Four Draws

	Charge and Blue Powder
1st Draw	20% 2 top and 2 bottom rows
2d Draw	32% whole furnace.
3d Draw	39% whole furnace.
4th Draw	9% whole furnace.

After establishing the percentage of each draw, giving the best recovery for a particular ore, the fireman may be instructed to so bring his furnace; but, as a rule, the proportion of metal drawn in no way controls the firing of the furnace.

Composition of Spelter.—Iron and lead are nearly always determined in the spelter, as they practically control its classification. Cadmium is occasionally required.

The following results on spelter made at different plants give some idea as to the per cent of these elements existing in the zinc, and shows the reduction in quantity of iron and lead in the spelter by the use of a front charge, either of coal or an ore low in iron and lead, the front charge being charged in the mouth of the retort. This, of course, increases the cost per ton.

Smelting a Colorado ore high in iron, and using the front charge, the following results were obtained:

1st Draw Charge		2d Draw Charge		1st Draw Blue Powder		2d Draw Blue Powder		3d Draw	
Fe%	Pb%	Fe%	Pb%	Fe%	Pb%	Fe%	Pb%	Fe%	Pb%
0.032	1.09	0.132	1.50	0.064	0.83	0.088	1.48		
0.016	1.03	0.110	1.60	0.050	0.92	0.080	1.48	0.37	2.18
0.020	1.09	0.076	1.59	0.06	0.97	0.072	1.39		

The general average, exclusive of third draw, would be Fe = 0.055 per cent, Pb = 1.20 per cent.

Smelting Joplin and carbonate ores low in Fe, with no front charge, all draws averaged Fe = 0.042 per cent, and Pb = 1.41 per cent.

Smelting a high iron ore with front charge, all draws average Fe = 0.061 per cent, and Pb = 1.31 per cent.

	Average 2d Draw Fe%
Not using front charge 4 days	0.089
Using a front charge 8 days	0.055
Reduction due to use of front charge	0.034

Smelting Joplin ore, average of charge and blue powder:

	Pb%		Pb%
1st Draw, 2 top rows	0.64	2 bottom rows	0.70
2d Draw, 2 top rows	0.88	2 bottom rows	0.79
3d Draw 2 top rows	1.13	2 bottom rows	1.00
	0.88		0.83

Brass Special.—In using ores low in iron and lead it is sometimes possible to separate the first-draw charge and blue powder from the other draws, provided it does not make the latter too high in iron and lead. Spelter of the following analyses would probably pass for brass special: Fe, 0.03 per cent; Pb, 0.65 per cent; Cd 0.30 per cent.

Sampling Spelter

In order to obtain a sample representative of a lot or car of spelter a certain number of plates from each draw should be drilled and the drillings mixed, each draw to itself. Then from these samples aliquot parts (representing the weights of each draw in the lot or car) are thoroughly mixed, from which no less than 20 grams should be taken for a sample.

Granulated Sample

Many of the plants are now having the fireman of the block take a small sample of the molten zinc from one or two ladles of each draw, just before molding. This should be poured from a height of several feet in as small a stream as possible, into a clean bucket containing clean water. The water is decanted off, the sample dried and transferred immediately to a clean pan or sack.

Such a sample will go into solution very rapidly, which is a decided advantage in controlling the iron and lead in the spelter. In taking a granulated sample, the chance of "salting" from the steel drill is also removed. The following test illustrates this: While the metal drawer at one of the plants was molding a plate of zinc the writer took thirteen samples from the stream. The plate was then drilled in thirteen places and all the samples were analyzed for Fe. The comparison is given in the accompanying table.

Controversies often arise between the producers and consumers of spelter with respect to the iron contents. In certain cases this may be due to "salting," but it is more apt to be due to the fact that four or even six draws, each with a different analysis in iron and lead, may be loaded into a car or piled into one lot for ship

Comparison of Analytical Results

No.	Percentage Iron—Drilled	Percentage Iron—Granulated
1	.084	.084
2	.048	.058
3	.122	.068
4	.110	.104
5	.072	.080
6	.096	.068
7	.072	.070
8	.104	.082
9	.062	.094
10	.068	.078
11	.094	.080
12	.084	.068
13	.084	.058
Average	.082	.077

ment. It would therefore be impossible for the buyer to obtain an accurate sample unless he sampled every plate, making a composite sample of all. It is interesting to note that while the third draw is only about 10 per cent of the total metal produced, it may actually contain as high as 50 per cent of the total iron in the spelter, and a large proportion of the total lead, as will be seen from the following example. Assuming 100 lb. of spelter produced, we have the following results:

	Total lb.	Percentage Fe	Percentage Pb	Pounds Fe	Pounds Pb
Draws exclusive of 3d Draw	90	0.055	1.20	0.050	1.080
3d Draw	10	0.350	2.18	0.035	0.218

Treatment of Retort Residues

General.—In view of the fact that a considerable proportion of the ores treated at the spelter works (primarily for the extraction of zinc) carry silver, gold, lead and copper, either singly or in various combinations, the proper method of handling the residues is one of considerable importance, and will probably be given more attention in the future than in the past.

The method of treating the residues not only varies at the different plants, but sometimes at the same plant, according to conditions and the analysis of the material. Whenever the residue is of such a value as to overcome the treatment charge, freight, etc., and leave a fair net profit per ton, it will, as a rule, pay better to ship direct without any attempt at concentration. If the residue, however, is too low in value to show any profit on direct shipment, some of the following means of concentration may be and are often adopted: dry screening, jigging, burning, smelting.

Dry Screening

This is the simplest and cheapest method of concentrating the residues, and often gives a very good grade of concentrate without much loss, provided the screen openings are not too fine. Under ordinary conditions a screen of No. 16 wire having 5 or 6 meshes to the linear inch is as fine as should be used. This size will remove only the clean, coarse coal or coke, provided the residue and fuel have in no way been sintered together during the process of extracting the zinc, or by permitting them to become wet or oxidized previous to screening. In either of the latter cases it would not pay to screen.

As previously stated, when the residue shows a direct profit it seldom pays to screen. A possible exception to this is where the lead runs just below 5 per cent, and is paid for as iron excess, or 10c. per unit. By screening through a screen just coarse enough the lead may be brought slightly above 5 per cent, and then be worth about 30c. per unit. Again, the lead in the blue powder residue will, as a rule, run as high as the lead in the charge residue. It may, therefore, occasionally pay to screen the blue powder residue and mix it with the charge residue.

Miscellaneous Screen Tests

No. 1

Using a 3-mesh screen 7/32-in. opening

Charge Residue

Mesh	Weight Lb.	Weight Tons	Per Cent	Analysis SiO2	Fe	Zn	S	Pb	Ag	Au	Gross Value	Treatment, Freight, Etc.	Net Value
Charge Residue													
Plus 3	3819	1.91	32.3	13.3	10.0	6.0	3.8	2.5	7.8	0.16	$7.04	$5.70	−$1.34
Minus 3	8025	4.01	67.7	10.6	13.4	10.0	5.5	7.21	1.7	0.27	13 91	5.70	− 8.21
		5 92	Crude Residue=72%								$11.69	$5.70	$5 99
Blue Powder Residue													
Plus 3	1617	0 81	35.2	18.0	7.4	6.2	2.1	2.2	3.7	0.09	$2.80	$5.70	−$2 90
Minus 3	3008	1.50	64.8	11.1	9.4	8.7	3.8	6.2	6.7	0 14	8.16	5.70	+ 2 46
	4625	2 3	Crude blue powder residue=28%								$6.31	$5.70	$0.61

From the above figures it is apparent that it would not pay to screen the charge residue, while it would pay to screen the blue powder residue, as illustrated below:

2.3 tons per day per block at $0.61	$1.40
1.5 tons per day per block at 2.46	3.69
Difference per day	$2.29
On a 5-block plant per month	$345.00

The screening may be done by hand, but can be accomplished cheaper mechanically.

No. 2

Using a screen of 5-Mesh No. 15 Wire

Analysis

	%	Ins.	SiO_2	Fe	Zn	Pb	Ag
Crude residue	100	27.5	18.0	20.9	4.0	6.1	10.5
Plus 5 mesh	26	32.8	22.8	14.8	2.8	3.4	7.0
Minus 5 mesh	74	25.4	15.0	22.2	4.5	7.0	12.0

No. 3

Using a screen of 5-Mesh No. 15 Wire

Crude residue	100.0	...	13.7	24.0	7.2	6.5	10.9
Plus 5 mesh	31.3	...	16.6	12.2	4.9	2.7	4.8
Minus 5 mesh	68.7	...	12 0	28.0	7.7	7.1	12.4

No. 4

Using a screen of 5-Mesh No. 16 Wire

Crude residue	100	...	13.8	24.7	7.0	2.5	10.4
Plus 5 mesh	36	...	15.0	15.2	5.0	1.8	6.3
Minus 5 mesh	64	...	13.0	30.0	8.0	3.0	12 8

No. 5

Using a screen of 6-Mesh No. 16 Wire

Crude residue	100	...	15.0	19.8	6.6	2.0	7.7
Plus 6 mesh	47	...	16.8	10.9	5.4	1.5	3.5
Minus 6	53	...	13.3	27.6	7.6	2.5	11.4

From such data as the above it is a simple matter to calculate the advisability of screening, and some idea is gained as to the screen best adapted, provided the results warrant the operation. The percentages on and through the screen, indicated as plus and minus, vary somewhat according to the degree of fineness of the charge fuel used in the furnace. In fact, the size of the charge fuel really governs the size of the screen opening.

Jigging Residues

Several plants have tried out the Harz type of jig on residues, but the success is very doubtful. At least the method has gone out of use at the plants of this country so far as the knowledge of the writer goes. One company has also tried out the Hancock jig, but judging from results, and records of the writer, and the fact that the method has not become adopted, it can hardly be considered satisfactory.

The results here submitted might be materially improved by the use of an automatic feed to the jig, and the further concentration of No. 4 hutch in some manner. Where the residue has been permitted to weather and oxidize, it is even still harder to effect a good separation. The first residue direct from the furnace gives a good grade of concentrate, but, due to the intimate mixture of the heavy fine slate in the coal and the fine ore, there is too much loss in the tailing. While the following results are not conclusive they give an indication of what may be expected.

The plant was designed and built to handle 100 tons per day, and consisted of the following equipment:

1 54-in., 80-hp. boiler.
1 52-in., 80-hp. boiler.
1 14-in. Blake crusher, 300 r.p.m.
1 set of rolls, 16 in. by 14 in.
1 main elevator to screen.
1 revolving trommel, 34 in. by 6 ft., with 6-mesh No. 16 wire, 18 r.p.m.
1 No. 4 centrifugal pump, 900 r.p.m.
1 4-compartment Hancock jig, 190 strokes per minute, ¼ in. vertically and 3/16 in. laterally, with following screen dimensions:
Hutch No. 1, 39¾ in. by 2 ft.
Hutch No. 2, 41¾ in. by 2 ft.
Hutch No. 3, 33 in. by 2 ft.

In addition to the above, a small Harz jig was later installed, with a view of separating the coal from the slate by handling the returns from the screen. While this separation was satisfactorily accomplished, the coal product ran considerably higher in ash than the original coal. As to the value of its reducing properties, the writer is not prepared to say. There is no doubt, however, that the plants in the United States will investigate this question further in the future.

General Operation

The residue was fed by hand into the crusher (through which a small stream of water flowed) and elevated to the revolving screen. The undersize was spouted to the Hancock jig and the oversize to the rolls. As previously stated, there was no automatic feed, and it was therefore difficult to keep the screens properly bedded at all times. Another difficulty encountered was the collecting of very small pieces of metallic zinc and iron upon the first screen bed, necessitating the frequent readjustment of the bedding over this particular screen. The cutting out of the oversize or taking it to the Harz jig for separation of coal simply transferred the trouble. The question, however, is not a serious one, provided careful work be performed on the furnaces.

Cost of Concentrating by Jigging

Based upon feeding 100 tons of crude residue to the Hancock jig per 24 hours.:

	Old Residue	New Residue
Two engineers	$5.00	$5.00
Two hutch men	4.00	4.00
Four feeders	8.00	8.00
One helper	1.80	1.80
Teaming	6.00	...
One blaster	1.75	...
One helper	1.50	1.50
Labor on pond	1.50	1.50
Water	2.00	2.00
Blasting materials	1.13	...
Repairs	1.68	1.68
	$34.66	$23.98
Cost per ton crude	0.35	0.24
Cost per ton conc.	1.05	0.72

Test Run No. 1

Fresh Charge Residue—Time 8½ Hrs

	Percentage				Oz. Per Ton						Screens	
	SiO_2	Fe	Mn	Zn	S	Pb	Ag.	F.C.	V.M.	Mesh	Wire
Crude residue	11.0	29.7	0.84	5.5	3.1	3.4	5.4	...	..	...	..
Minus 5 M.	7.6	36.7	0.94	6.7	3.7	4.0	8.0	...	..	...	..
Hutch 1	5.6	38.9	1.06	7.0	4.0	5.8	11.0	...	.	6	14
Hutch 2	7.8	52.1	1.20	9.2	5.2	4.3	11.0	...	.	7	16
Hutch 3	18.6	31.1	1.00	7.7	4.0	2.8	9.3	...		6	14
Hutch 4	15.6	12.5	...	4.0	..	1.5	4.6	...	..	6	14
Tailings	13.2	7.4	...	3.0	..	0.7	3.6	...	..	...	..
Return to rolls	25.0	4.8	...	3.4	...	..	2.3	...	..	Ash	..
Coal material	...	2.7	...	...	0.7	...	...	70.8	2.0	27.2	..
Recovery %	...	63.5	...	...	...	52.7	74.5	...	..	...	.

Weights and Values

	Dry Wt., Lb.	Value Per Ton	Cost Per Ton	Net Per Ton	Total Realization
Crude residue	61109	$5.11	$5.70	$0.59	$18.00
Minus 5-mesh	46076	7.58	5.80	1.78	40.94
Hutch No. 1	11250	...	...	...	....
Hutch No. 2	7260	...	...	...	....
Hutch No. 3	4640	...	...	...	....
Hutch total	23150	11.08	6.75	4.33	50.01
Hutch No. 4	8050	...	...	...	....
Tailing	21650	...	..	...	....
Slimes, etc.	8259	...	...	...	....

The above test shows that it would not pay to ship the crude residue, also a total difference between dry screening and concentrating of $9.07, or about 30c. per ton of crude residue.

Test Run No. 2

Fresh Charge Residue through ⅜-in. Trommel screen to Hancock Jig, Returned to Rolls Cut Out

	SiO_2	Fe	Pb	Ag	F.C.	V.M	Ash	Screens Mesh	Screens Wire
Crude residue	8.5	25.9	5.0	8.7	...	...	...	...	....
Hutch No. 1	4.1	51.7	11.5	15.2	...	...	...	6	14
Hutch No. 2	8.8	37.7	6.3	12.6	...	...	..	7	16
Hutch No. 3	12.0	28.8	3.7	10.3	...	...	...	6	14
Coal	...	...	...	...	72.0	1.9	26	....	....
Recovery	65.6	62.0	59.8	....	....	...	....	....	....

Weights and Values

	Wt.	Value Per Ton	Cost Per Ton	Net Per Ton	Total Realization
Crude residue	19,500	$8.03	$5.70	$2.33	$22.71
Hutch 1	4,671				
Hutch 2	1,862				
Hutch 3	659				
Hutch total	7,292	14.70	6.35	8.35	29.98
Coal	6,680				

The above shows a total difference of $7.27, or about 75c. per ton of crude in favor of jigging.

Test Run No. 3

Fresh Charge Residue Screened through 6-Mesh No. 16 Wire to Hancock Jig

	SiO_2	Fe	Pb	Ag	F.C	V.M.	Ash	Screen Mesh	Screen Wire
Crude residue	9.5	20.8	2.7	5.4	...	...	...	...	...
Hutch 1	5.8	57.0	5.5	9.6	..	.	....	7	14
Hutch 2	15.2	35.0	3.1	9.9	...	.	....	7	16
Hutch 3	18.4	21.1	2.8	6.4	...	...	...	7	14
Hutch 4	...	...	...	...	41.6	1.4	57.0	½ 5	14
Recovery	...	93.1	69.4	72.2	...	.	...	½ 7	18

Weights and Values

	Wt.	Value Per Ton	Cost Per Ton	Net Per Ton	Total Realization
Crude residue	66,000	$4.22	$5.70	$1.48	$48.84
Hutch 1	16,244	.	.	.	....
Hutch 2	8,136	.	.	.	...
Hutch 3	3,235	.	.	.	...
Hutch 1 and 2	24,380	10.50	6.75	3.75	45.76
Hutch 4	16,432	...	...	...	...

In this case it would certainly pay to concentrate. Hutch No. 4 would be of no value. In general, it was found impossible to obtain a good coal product from the Hancock jig.

Test Run No. 4

Blue Powder through ½-in. Screen to Hancock Jig

	SiO_2	Fe	Pb	Ag	F.C	V.M	Ash	Screen Mesh	Screen Wire
Minus ½ in	13.6	12.6	7.5	5.3	...	...	...	...	...
Hutch 1	12.4	29.2	13.8	11.3	...	...	...	7	18
Hutch 2	19.0	25.9	9.6	10.0	...	...	...	7	18
Hutch 3	23.8	16.9	5.8	6.5	...	...	...	7	18
Hutch 4	21.0	9.6	3.2	4.0	...	...	...	½ 7	18
								½ 5	14
Coal	...	...	...	...	57.3	2.5	40.5	...	...
Recovery	...	51.9	58.8	54.2	.	...	...	...	..

Weights of materials not recorded, but it would probably pay to concentrate

TEST RUN NO. 5

Blue Powder through 5-Mesh to Hancock Jig—77.7%

	SiO_2	Fe	Zn	Pb	Ag	F.C.	V.M.	Ash
Minus 5-Mesh	16.6	14.5	7.2	–5.8	7.5	....	....	....
Hutch 1	6.0	37.8	12.0	–16.3	15.5	....	....	....
Hutch 2	12.2	33.4	11.8	13.3	14.8	....	....	....
Hutch 3	24.0	19.8	10.4	8.7	10.0	....	....	....
Hutch 4	19.0	8.7	4.4	3.4	4.6	40.5	0.8	58.7
Coal	11.4	6.2	....	....	....	56.6	4.5	39.0
Returns	16.2	....	....	....	....	56.5	1.1	42.4
Orig. Coal	10.3	2.2	....	....	....	66.6	7.5	25.9
Recovery	...	45.5	....	52.8	41.5	....	....	....

Weights and Values

	Wt.	Value Per Ton	Cost Per Ton	Net Per Ton	Total Realization
Through 5-Mesh	56,600	$5.73	$5.70	$0.03	$0.85
Hutch 1	6,840				
Hutch 2	2,440				
Hutch 3	3,372				
	12,652	13.77	5.66	8.11	51.33
Coal	14,000 (approximately)				

There is a decided advantage in concentrating, which is mainly due to the increase in the per cent of lead, which increases its value per unit, and a lower treatment charge.

TEST RUN NO. 6

Blue Powder Residue from Very Fine Leady Ore, Hancock Jig

	SiO_2	Fe	Zn	Pb	Ag	Screens Mesh	Screens Wire
Crude residue	10.1	12.7	5.8	8.7	6.3	....	....
Hutch 1	7.3	26.8	11.8	28.6	18.0	6	16
Hutch 2	10.8	27.8	11.0	19.2	14.6	7	18
Hutch 3	18.1	32.5	9.0	13.1	10.6	7	18
Hutch 4	21.0	14.2	5.8	8.0	6.5	....	....
Slimes	....	....	....	7.1	....	....	....
Recovery	....	37.3	33.8	44.3	43.0	....	....

Weights and Values

	Wt.	Value Per Ton	Cost Per Ton	Net Per Ton	Total Realization
Crude	46,160	$6.60	$5.70	$0.90	$20.79
Hutch 1	3,290				
Hutch 2	2,585				
Hutch 3	2,600				
Hutch total	8,475	17.37	4.73	12.64	53.47

A total difference in favor of concentrating of $32.68, or $1.41 per ton of crude, although the recovery is low.

This class of material could not be concentrated by dry screening, owing to its sintered nature.

The general conclusions drawn by the writer from the preceding tests are: First, that when the crude charge residue shows an appreciable net value it will not pay to concentrate by the Hancock jig; second, that the blue-powder residue seems to concentrate better, and may pay to jig, whether it shows a net value or not in the crude; third, that the fresh residue concentrates much more satisfactorily than the old or weathered residue.

With respect to the last test, Hutch No. 4 probably could be further concentrated by means of tables, vanners, or otherwise. While it would not be considered good practice to retreat Hutch No. 4 over the jig, the following test indicates that the jig may be overloaded, and that an automatic feed to same might improve the results.

HUTCH 4 REJIGGED

	Wt.	SiO_2	Fe	Zn	Pb	Ag
Crude	12,800	17.8	21.5	5.5	3.0	6.8
Hutch No. 1	720	11.4	31.5	10.5	6.7	10.5
Hutch No. 2	400	10.8	32.5	9.6	5.3	11.0
Hutch No. 3	440	12.0	29.5	8.8	4.0	9.3
	1,560					

This recovery looks very good, but owing to the incompleteness of the test no definite conclusions can be drawn. In fact, all of the tests made upon Hutch No. 4 material merely indicate the difficulty of further concentrating same.

SCREEN TEST ON OLD RESIDUE AFTER PASSING SCREEN OF NO. 16 WIRE, 6 MESHES PER LINEAR INCH

	Oz.	% of Crude	Insol. %	Insol. % of Crude	Fe %	Fe % of Crude	Zn %	Zn % of Crude	Pb %	Pb % of Crude	Ag %	Ag % of Crude
Crude	156	....	20.4	....	24.3	....	7.0	....	5.77	....	8.5	....
Plus 10 mesh	36	23.0	22.8	25.8	14.8	14.1	6.0	20.0	1.9	7.7	5.0	13.6
Minus 10 mesh	40	25.6	21.4	26.9	19.1	20.2	4.7	17.2	3.0	13.5	6.5	19.6
Minus 18 mesh	36	23.1	18.6	21.7	24.4	21.9	5.8	19.2	5.3	21.5	8.5	23.1
Minus 40 mesh	24	15.4	16.4	12.4	31.0	19.7	7.2	15.9	6.6	17.8	10.5	16.7
Minus 80 mesh	12	7.7	16.4	6.2	31.0	9.8	7.8	8.6	7.2	9.8	10.6	9.6
Minus 100 mesh	3	1.9	16.4	1.6	31.7	2.5	8.6	2.4	8.2	2.8	11.3	2.6
Minus 150 mesh	6	3.8	15.8	3.0	30.9	4.9	8.8	4.9	7.7	5.2	11.0	5.0
	157	100.5	..	97.6	..	93.1	..	88.2	..	78.37	..	90.2

TEST RUN ON RESIDUE

Sutton, Steele and Steele Table, Coarse Top

	Lb. Crude	SiO_2	Fe	Zn	Pb	Ag	Au	S
Head	291	....	10.0	24.5	4.0	tr.	5.2	.01	2.0
Concentrate	121	41.6	2.6	50.0	7.2	2.4	8.2	.02	3.4
Middling	13	4.5	20.4	10.6	3.6	0.7	3.6	.01	2.7
Tailing	124	42.6	10.3	2.4	0.6	....	0.7	tr.	....
Recovery on conc.	....	....	....	85.2	74.8	....	65.6	....	....

Magnetic separator test on material from Hutch No. 4, from Hancock jig treating old residue. Tests made upon the magnetic separator gave a high degree of concentration with respect to the iron, but the lead and silver were inclined to remain with the tailings.

WILFLEY TABLE TEST ON HUTCH NO. 4 MATERIAL

	Wt. Lb.	%	Insol.	Fe	Zn	Pb
Crude	93	....	27.5	18.7	5.4	2.5
— 20 + 24	..	....	26.4	17.9	4.3	2.3
Conc.	2	13.3	23.7	26.4	12.3	5.7
Tail	13	86.7	30.5	16.2	4.9	2.0
— 24 + 60	..	....	25.6	18.7	4.6	2.1
Conc.	14	33.3	24.0	29.1	7.0	3.9
Tail	28	66.7	28.0	14.4	3.5	1.6
— 60	..	....	26.2	21.0	5.9	2.9
Conc.	9	25.7	13.9	33.6	12.0	6.5
Tail	26	74.3	31.0	18.7	5.1	2.0

Recovery Pb = 52% Fe = 42.5

SCREEN TEST ON HUTCH NO. 4 MATERIAL

	Oz.	% of Crude	Insol. %	Insol. % of Crude	Fe %	Fe % of Crude	Zn %	Zn % of Crude	Pb %	Pb % of Crude	Oz	Ag % of Crude
Crude	77		29.0		26.0		7.4		3.4		8.5	
Plus 10 mesh	12	15.6	37.4	20.2	23.0	14.0	6.4	13.5	2.8	13.1	7.0	12.9
Minus 10 mesh	20	26.0	35.0	31.4	23.2	23.0	5.8	20.4	2.5	19.2	8.0	24.6
Minus 18 mesh	20	26.0	24.4	22.0	27.3	27.5	7.4	26.0	3.4	26.2	9.4	28.9
Minus 40 mesh	12	15.6	18.8	10.3	30.0	18.0	9.6	20.2	4.4	20.4	10.0	18.5
Minus 80 mesh	3.4	4.4	17.4	2.7	29.6	5.0	10.5	6.3	4.9	6.5	9.6	5.1
Minus 100 mesh	2.3	3.0	17.0	1.8	30.3	3.5	10.6	4.2	5.5	5.0	9.5	3.4
Minus 150 mesh	1.9	2.5	16.0	1.4	30.3	4.0	11.4	3.9	6.6	5.0	11.5	3.4
	71.6	93.7		89.8		95.0		94.5		95.4		96.8

Burning Residues

A certain degree of concentration may be obtained by burning the carbonaceous material contained in the residue, or at least the greater proportion of it. There are two special advantages gained by this method aside from the concentration, namely: the removal of the carbonaceous material, which is a detriment in smelting, and the sintered form of the product, which enhances its smelting value due to its mechanical condition and reduced dust loss in smelting. One of the zinc plants has had this method in practical use for some time. The residues are simply piled out upon the ground, over pipes or channels through which a blast of air is forced after the ignition has been started, the burning process being kept up until the greater part of the carbonaceous material has been consumed. The

blast is then turned off and the pile allowed to cool, after which it is broken up, loaded into cars, and shipped. The advantages of the process undoubtedly overbalance any metal losses.

Smelting Residues

A great many tons of residue containing precious metals have been smelted during the past 12 years at the various lead smelters, using a small proportion of residue mixed in with the general charge. Only one attempt, however, has been made in this country to smelt the residues as the principal burden of the charge. This experiment was made about 1903, at one of the zinc company's plants.

As there is a difference of opinion regarding the best method of treating the residues, the writer herewith gives his personal notes upon the above mentioned experiment, and a deduction of what might possibly be done under more favorable circumstances, with a view of arriving at a comparison between smelting and other processes of concentration.

Notes from Smelting Experiments

The furnace was only 36 in. by 90 in. at the crucible and 14 ft. from center of tuyeres to feed floor. The furnace being small, and a high per cent of zinc on the charge, it had to be let out frequently to bar off the accretions, the longest run being about six weeks.

Average Percentage Analysis of Materials Smelted

	SiO_2	FeO	CaO	MgO	ZnO	Al_2O_3	S	Pb	Cu	Ag	Au
Mo. iron ore	10.0	65.0	..	..	..	..	..	..	..	..	..
Lime rock	.. 1.5	..	52.0	..	..	..	..	..	..	..	..
Mo. galena	.. 1.5	2.4	..	..	9.5	..	11.0	74.0	..	..	..
Av. of ore beds	50.8	16.2	..	..	4.6	..	3.3	9.1	..	..	..
Residue	.... 10.5	38.5	..	..	18.0	..	4.8	2.2	1.0	10.0	.03
Rst. matte	.. 9.0	48.0	3.0	..	10.0	..	4.0	9.9	3.0	21.0	.06
Barrings	.... 18.8	24.4	5.0	..	14.5	..	6.0	25.4	..	13.0	.07
Coke ash	... 27.0	28.4	14.9	4.5	..	19.7	..	..	..	..	..

	H_2O	V.M.	F.C.	Ash	S
Coke	1.2	2.3	85.7	11.1	0.9

Analysis of Products

	Bullion		Slag							Matte			
	Ag	Au	SiO_2	FeO	MnO	CaO	ZnO	Pb	Ag	Ag	Au	Pb	Cu
Feb.	90.1	1.15	31.2	35.9	1.0	14.5	10.3	0.88	0.98	19.0	.04	8.7	1.5
March.	93.1	1.63	31.3	37.2	1.0	13.9	11.1	0.71	1.30	21.0	.06	8.0	2.5
April.	104.3	1.59	29.8	37.7	2.7	13.9	11.4	0.52	1.40	23.0	.07	7.0	3.5
May	90.0	1.24	30.0	37.3	2.2	14.1	9.3	0.86	1.10	25.4	.07	5.1	4.0
July	78.7	1.00	32.2	37.4	1.0	13.9	9.8	0.50	1.15	21.3	.03	8.9	4.0
August	90.8	1.21	31.2	37.1	1.7	13.7	9.6	1.10	1.60	23.1	.08	9.8	3.0
Sept.	65.3	2.58	32.0	39.7	0.8	14.9	8.1	0.80	1.30	18.6	.06	7.8	2.3
Av	87.5	1.49	31.1	37.5	1.5	14.1	10.0	0.77	1.26	21.6	.06	7.8	3.0

Average Record of Furnace Operations for the Above Seven Months

Oz. Blast	Tons Per Fur. Day	% of Pb. on Chg.*	% of Coke	% Matter Produced	—% Saving— Ag	Au	Pb
19.0	45.6	9.1	13.0	7.2	90.8	92.4	92.0

While the office record showed a loss of about $2,000 per month, it was due not so much to the metallurgical failure to smelt the residues as it was to the small size of the furnace and the high percentage of zinc left in the residues at that time; also to the high minus margin on the Missouri galena, due to the conditions under which it was bought.

The period of the experiment was 273 days, while the actual furnace days were only 149. The results are, therefore, no criterion of what may be accomplished under more favorable conditions.

To anticipate what may be accomplished under more favorable conditions, and reduce the above results to

Results Actually Obtained Basis Upon 149 Furnace Days

	Per Day	Per Fur. Day
Labor and overhead expenses	$71.00	$117.20
Sampling and assaying	2.30	4.15
Supplies	2.00	3.72
Repairs and renewals	4.90	9.00
	$80.20	$134.10

	Tons Per Day	Minus Margin	
Galena	2.8 ×	— 6.05 =	— 16.94
Lime rock	6.5 ×	— 1.09 =	— 7.09
Iron ore	6.7 ×	— 4.25 =	— 28.48
Coke	6.1 ×	— 8.20 =	— 50.02
	— 22.1		— 102.53
			— $236.63

		Plus Margin	
Residue	13.3 ×	+ 9.34 =	124.22
Ores	12.2 ×	+ 3.76 =	44.87
	25.5		+ 169.09
Loss per day			— $67.54
Loss per month			$2,026.20
Loss per ton of residue			— $5.07

a fairer comparison with other methods of treating the residue, it is not unreasonable to assume the following:

1—Per cent of zinc in the residue, 7 instead of 14.

2—Due to this, a slag lower in iron could be run, thereby replacing some of the Missouri iron ore with residue.

3—Larger furnace, treating 100 tons per day, at a less cost per ton.

4—Furnace down only 28 days out of the 273.

Results Upon Assumed Basis

	50 Tons Per Day	100 Tons Per Day	Per Fur. Day
Labor and overhead expenses	$71.00	$83.50	$89.40
Sampling and assaying exp.	2.30	4.60	4.95
Supplies expenses	2.00	4.00	4.28
Repairs and renewals expenses	4.90	5.80	6.21
	$80.20	$97.90	— $104.84

	Tons Per Day	Minus Margin	
Galena	5.6 ×	— 6.05 =	— $33.88
Lime rock	14.0 ×	— 1.09 =	— 15.26
Iron ore	9.0 ×	— 4.25 =	— 38.25
Coke	12.2 ×	— 8.20 =	— 100.04
			— 187.43
			— $292.27

		Plus Margin	
Residue	30.00 ×	+ 9.34 =	+ $280.20
Ores	24.4 ×	+ 3.76 =	+ 91.74
			+ $371.94
Profit per day			+ $79.67
Profit per ton of residue			+ 2.66

The comparison between smelting and shipping the residue direct would be as follows:

	Total Margin Per Ton of Residue	Cost Per Ton of Residue	Net Per Ton of Residue
Smelting	$12.40	$9.74	$2.66
Shipping	8.10	5.70	2.40

If the residue was dry screened it would show a better profit than above. It is therefore very doubtful if it will pay to smelt the residues, except under the most favorable circumstances, or when they do not constitute the bulk of the charge.

The above comparison is based upon a residue of the following analysis and valuation:

Analysis

SiO_2, 10.5%; Fe, 32.7%; Pb, 2.3%; Ag, 10 oz., and Au .03 oz. per ton.

Valuation

Smelting	*Shipping*
Market Ag = 59c per oz.	Ag = 59c per oz.
95% of Ag	95% of Ag.
$18 for Au @ 92%	No pay for Au
90% of Pb @ 3c per lb. less refining.	10c. per unit for Pb.
10c. per unit for excess iron	10c. per unit for excess iron

The Filter-Press

By D. R. Sperry

PERHAPS no machine employed in the chemical industry at the present day is so little understood and at the same time so widely used as the filter-press. Beyond a doubt this is due largely to the great variety of ways in which the machine is used. Persons who are in intimate contact with filter-presses as used in their particular branch of the chemical industry are informed regarding them only as arranged and used in their process. They know very little of the hundred and one other arrangements in which the filter-press can be used and is used in other chemical processes. General knowledge of the filter-press, therefore, is not likely to be found among the actual users of the apparatus. The lack of general information regarding it in text-books and in technical publications, due probably to the reasons given above, produces a lack of information on the subject among those who are not already users. It is quite probable that there are a great many instances in chemical processes wherein the filter-press could be used to advantage were it possible for engineers and chemists to obtain a broad general understanding of the device. It is the writer's purpose to convey by means of this article a general knowledge of the filter-press, and it is his earnest hope that it may prove an efficient tool for engineers and chemists in solving their problems.

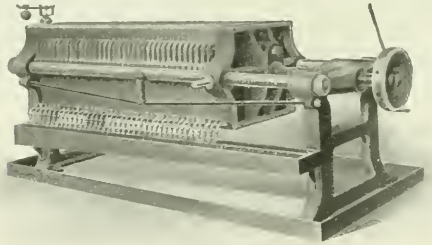


FIG. 1. FILTER-PRESS

Field of the Filter-Press

The field of the filter-press is very broad, which explains its great versatility, inasmuch as it may be used wherever the great principle of the separation of solids from liquids is employed. There are very few cases indeed in the various branches of the chemical industry where it is not necessary in some way to separate solids from liquids. In most of these lines, not all, to be sure, the filter-press may be used. Its field extends also to a certain extent into that of lixiviation and extraction, as will be explained later.

What the Filter-Press Does

The filter-press does two important things, namely:

(a) Separates solids from liquids.

(b) Washes, lixiviates or extracts.

The first is performed by forcing or pumping the liquid containing the solids through a filter-base, usually cotton duck, thus retaining the solids in the cells or chambers of the filter-press. The liquid flows away, usually through cocks placed on each cell. The second process, called washing, consists in forcing water or some other liquid into the filter-press in such a way that it flows through the deposited solids, displacing therefrom the liquid contained in the pores which may later be recovered from the wash. Sometimes the wash water dissolves some desirable substance in the cake or solids, permitting its recovery later.

The filter-press can also cause thorough precipitation of a substance contained in the liquid by reason of the intimate contact which the liquid necessarily makes with the solids, causing the precipitation, as it passes through the cake.

The filter-press may separate solids from liquids, maintaining the process at some desired temperature. Thus a substance can be chilled and crystals filtered out, or a substance crystallizing at ordinary temperatures can be filtered hot in order to remove impurities and not crystals.

Commercial Uses of the Filter-Press

Some of the commercial uses of the filter-press are the following:

(a) Making dull liquids clear and sparkling for appearance sake only, as in cider, near-beers, liquid soaps, etc.

(b) Removing substances from liquids for re-use or which would injure the product if allowed to remain, as in removing Fuller's earth or bleach from lard,

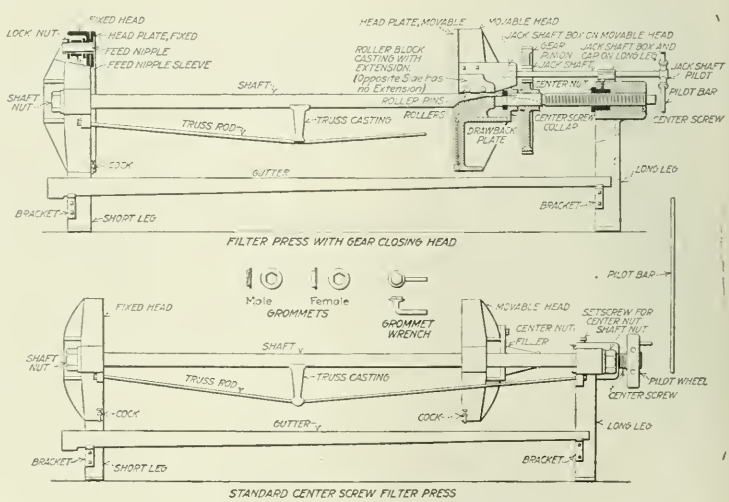


FIG. 2. NAMES OF PARTS OF A FILTER-PRESS

nickel from hydrolized vegetable oils, lime from sugar juices, etc.

(c) To separate a valuable liquid from a mass and then dissolve out or lixiviate some valuable substance contained in the solids, as in the treatment of cyanide slime in gold metallurgy.

(d) To separate a valuable mass from a liquid and then to lixiviate the valuable portion of the mass, the liquid being used solely as a conveyor for the mass, as lixiviating ground quartz in gold metallurgy after it has been deposited in the press by means of water.

(e) To reduce a muddy mass to a more convenient form, as in sewage sludge, china clay, etc.

(f) To save fuel in evaporation by removing the greater part of the moisture in the filter-press, as in the manufacture of lithopone, white lead, etc.

(g) To aid precipitation by mixing a substance causing precipitation with the liquid and pumping the mixture in a filter-press, as in gold metallurgy where zinc-dust is added to cyanide solution and is fed into a filter-press, the intimate contact of the cyanide solution causing gold to precipitate as it flows through the cake of zinc-dust.

(h) To crystallize out a substance which at ordinary temperature is liquid, by filtering in a refrigerated filter-press at which temperature crystals form, as in filtering certain oils.

(i) To clarify a substance which at ordinary temperature is crystalline, by filtering in a steam-jacketed filter-press at a temperature too high for crystals to form, as in Glauber's salts, where hydroxide of iron is removed.

(j) To separate a solid from an unstable liquid in a closed-discharge filter-press where the liquid does not come in contact with the atmosphere, as in certain varnishes and in cases where the liquid evaporates easily, as alcohol.

Advantages of the Filter-Press Over Other Forms of Filters

The advantages of the filter-press over other forms of filter are as follows:

(a) Includes the greatest amount of filter area per unit of floor space.

(b) Cost of filter area per square foot the lowest.

(c) Lowest cost of maintenance and repairs.

(d) Lowest operating expense due to the fact that common labor can operate a filter-press.

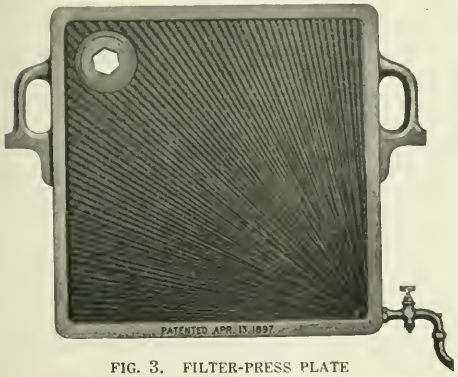


FIG. 3. FILTER-PRESS PLATE

At this point it is well to show what a filter-press looks like, and for that purpose there is shown in Fig. 1 a much used type. Cursory examination shows that it is a machine consisting of two general parts, namely, a screw-press supported on legs and a number of plates resting on the bars of the press and held together between the heads. Minor attachments consist of a row of cocks and a gutter. This machine is a filter-press in one of its most simple forms.

Definition of a Filter-Press and a Popular Misconception

A filter-press is a press which is employed to hold together the component parts of a filter.

A popular misconception of the name "filter-press" is that it is a machine which both filters the solids out of a mixture and squeezes or presses the solids as well. Many also imagine that a filter-press is some kind of a

FIG. 4. FILTER-PRESS GROMMETS

hydraulic press after the order of oil presses which squeeze the oil from seeds. The definition given above tells us that the filter-press is a press which presses a filter, just as a letter-press is a press that presses letters, or a hay-press is a press that presses hay. It should be remembered that while a filter-press presses a filter, it does so only to hold the filter together and not to press the solids within the filter.

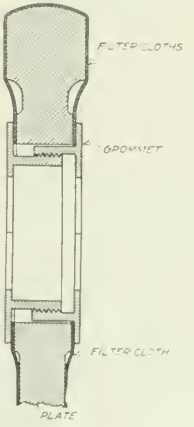


FIG. 5. SECTION THROUGH PORTION OF FILTER-PRESS PLATE SHOWING POSITION OF GROMMET WITH FILTER CLOTH IN PLACE

Names of Parts of the Filter-Press

In Fig. 2 are shown the names of parts of a filter-press both with and without gears for closing. It is quite interesting to note the great variety of names which users of filter-presses have given to the various parts. This is to be expected, of course, as up to the present time there has been no way of properly determining the correct names of parts. For example, the small parts called grommets, used to hold the canvas to the plates, have been called lock-nuts, cloth holders, flanges, ferrules, clamps, etc. Such a multiplicity of terms leads to confusion, and, therefore, in this article the names of parts given in Fig. 2 will be used exclusively.

Filtration Without Frames

The simplest form of filtration in a filter-press is that in which recessed plates are used. In Fig. 3 is shown a recessed plate with grommet screwed in place. To use these plates, they are first "clothed"; that is, a piece of the filter-base, usually cotton duck, is cut long enough to lay over the top of the plate and cover both sides. A hole is cut in the cloth on each side of the plate where it covers the grommet hole, and the grommet is applied. In Fig. 4 is shown the grommet hole

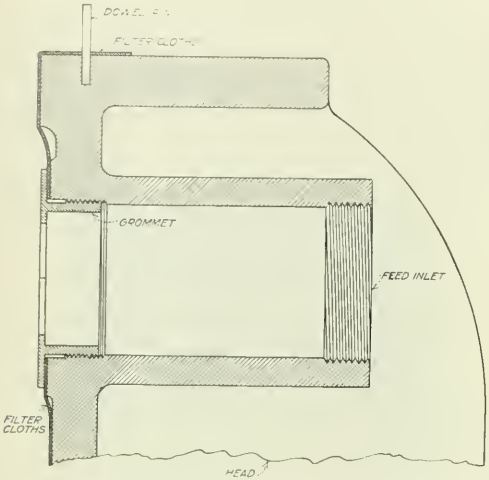


FIG. 6. SECTION THROUGH PORTION OF FIXED FILTER-PRESS HEAD SHOWING HALF-GROMMET AND FILTER CLOTH IN PLACE

in a plate (left-hand side), three grommets, one of which is unscrewed (left center of picture) and a grommet in place with cloth properly applied to plate (right side of picture). The grommet when thus screwed in place holds the cloth tightly down against the finished portion of the plate surrounding the grommet hole. A cross-section through the grommet hole when thus in place is shown in Fig. 5. The surface of both of the heads of the filter-press is similar to that shown on the plate in Fig. 3, except that on the movable head there is no grommet hole. A cloth is thrown over the surface of each head and a hole cut only in the cloth on the fixed head where it covers the grommet hole. A half-grommet, usually the male part, is screwed into the grommet hole of the fixed head, thus holding the cloth to the finished surface, surrounding the same in a manner similar to that done in the plates. A cross-section of a portion of the fixed head through the half-grommet is shown in Fig. 6. There are usually provided two dowel pins on the top of the heads, by means of which the cloth can be kept from falling down. This can be noted in Fig. 6.

When all the plates and heads are thus clothed, the plates are placed within the filter-press. A cross-section through the filter-press and plates when this is done is shown in Fig. 7. A study of this cross-section will disclose the fact that when the plates and heads are clothed as described there is formed throughout the length of the press a number of cells or chambers between each plate and between the heads and the adjacent plates. It will further be observed that all of the cells thus formed are connected together in multiple by means of the openings through the grommets. In fact, the grommets form a continuous channel running from head to head and joining together all of the chambers formed by the recessed surfaces of plates and heads. If now the screw of the filter-press is tightened so as to strongly compress the plates and heads together, the cloth covering the finished border of the plates and heads acts at that point as a packing, making the cells nearly watertight. It is interesting to note that there are two thicknesses of cloth at the joints, making a very thorough packing. Suppose now that a mixture of solids and liquid is introduced at the inlet of the fixed head. The result will be that the mixture will run the whole length of the press along the channel formed by the grommets filling all of the chambers or cells. If the mixture is placed under pressure there is but one thing which can happen, namely, the liquid of the mixture will flow through the cloth which bounds the chambers, while the solids will be left and may ultimately completely fill the chambers. The liquid, as it emerges from the back side of the cloth, comes into contact with the surface of the plate and is conducted by means of grooves, see Fig. 3, to one of the corners, where it

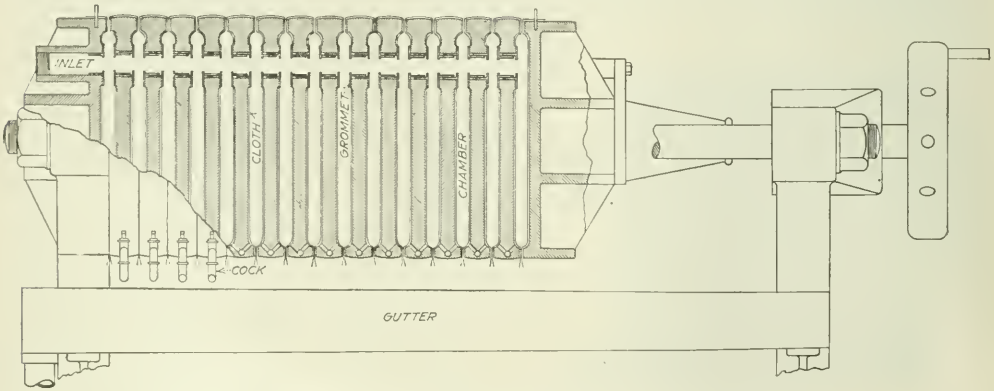


FIG. 7. CROSS-SECTION THROUGH FILTER-PRESS FITTED WITH RECESSED PLATES

flows into a small hole that leads to a cock placed on the corner of the plate. From the cock it empties into a gutter, from whence it is piped to a suitable receptacle. When the chambers become filled with solids or when the flow of liquid has become very small, the pressure is removed from the entering mixture and the screw of the filter-press is loosened so that the plates may be separated from one another. This is accomplished by pushing back the slide head as far as it will go and then pulling back each plate one by one, removing the solids as each one is brought forward. When the solids have thus been removed the plate which was last drawn up is slid back to the fixed head, the workmen seeing that the last traces of solids are removed from the cloth packing surfaces. Similarly, each plate is successively drawn back and inspected, until the movable head is reached, when it too is drawn back into place. Pressure is then applied to the screw and the filter-press is ready to receive another lot of the mixture. In the hands of the laborers who are accustomed to the work the process of removing the solids is not so long a process as one might suppose. The writer knows of a case where filter-presses containing forty plates have been opened, the solids removed, and closed again in an average time of fifteen minutes. Two common laborers perform the operation with ease.

NOMENCLATURE

Now that the simplest form of filtration in a filter-press has been described, it is well at this time to give the technical terms applied to the various steps in the operation as follows:

Clothing the Press.—Putting cloths on the filter-plates.

Closing the Press.—Squeezing the clothed plates together in the filter-press.

Filling the Press.—Pumping or otherwise forcing the mixture to be filtered into the filter-press.

Opening the Press.—Relieving the pressure on the screw of the filter-press and spreading the plates apart, at the same time removing the solids.

A Complete Cycle is the term applied to the successive operations of closing, filling and opening.

Cake means the solids deposited within the filter-press.

Filtrate.—The liquid issuing from the filter-press.

Batavia, Ill.

New York Section Société Chimie Industrielle

The organization meeting of the New York Section of the French Society of Chemical Industry was held at the Chemists' Club, New York, Friday evening, Jan. 18. As a result of a previous mail inquiry, about 150 chemists signified their intention of joining the new section.

The following officers were elected: L. H. Baekeland, chairman; Jerome Alexander, vice chairman; George F. Kunz, treasurer; C. A. Doremus, secretary. The council comprises Charles Baskerville, Henri Blum, M. T. Bogert, C. F. Chandler, Ellwood Hendrick, W. H. Nichols, R. E. Orfila, G. E. Valabrigue, E. P. V. Verge and Henri Viteaux. Following the election of officers a formal meeting was held, at which provision was made for election of the charter members. Dues were set at $7 per annum, and the date of the first meeting was announced as Feb. 15 in Rumford Hall, Chemists' Club.

M. René Engel, secretary of the parent society in France, was present and announced that the society would begin in February to publish its new journal, *Chimie et Industrie.*

Ordnance Department Needs Civilian Workers

The Ordnance Department of the Army urgently needs several thousand civilian workers, as specified in the following lists:

7700 clerical positions, including stenographers, typewriters, production clerks, statisticians, etc. Positions pay from $1,000 to $1,800 per year.

TESTING POSITIONS

200 engineers of tests of ordnance material, $1,500 to $2,400 a year.
200 assistant engineers of tests of ordnance material, $1,000 to $1,500 a year.

MECHANICAL TRADES POSITIONS

2500 machinists, $4.00 a day.
500 machine operators, $2.75 a day.
200 drop forgers, $5.75 a day (piecework).
300 tool makers, $4.50 a day.
Large numbers in practically all other trades.

DRAFTING POSITIONS

500 mechanical draftsmen, $800 to $1,800 a year.
50 gauge designers, $2,000 to $3,000 a year.
100 apprentice draftsmen, $480 a year.

INSPECTION POSITIONS

300 inspectors of small-arms ammunition, $1,500 to $2,400 a year.
100 inspectors of artillery ammunition (high-explosive shell loading), $1,500 to $2,400 a year.
100 inspectors of artillery ammunition (forgings), $1,500 to $2,400 a year.
100 inspectors of artillery ammunition (ballistics), $1,500 to $2,400 a year.
300 inspectors of field artillery ammunition steel, $1,500 to $2,400 a year.
300 assistant inspectors of field artillery ammunition steel, $3.50 to $5.00 a day.
500 inspectors of small arms, $1,500 to $2,400 a year.
100 inspectors of material for small arms, $1,000 to $1,800 a year.
100 assistant inspectors of cannon forgings, $1,500 to $2,400 a year.
100 assistant inspectors of finished machine parts, $1,500 to $2,400 a year.
100 assistant inspectors of gunfire control instruments, $1,200 to $1,500 a year.
50 assistant inspectors of steel helmets, $1,000 to $1,800 a year.
50 assistant inspectors of cleaning and preserving materials, $1,000 to $1,800 a year.
400 inspectors and assistant inspectors of powder and explosives, $1,400 to $2,400 a year.

For further information apply to the representative of the United States Civil Service Commission at the post office or custom house in any city, or to the Civil Service Commission in Washington, D. C. Except for the positions of stenographer and typewriter, typewriter operator, multigraph operator, and general clerk, applicants are not assembled for a written examination, but are rated principally upon their education, training and experience, as shown by their applications and corroborative evidence. The positions are for men only, except in the clerical work, where women are also accepted.

Intensive Toluol Production—I

Proposed Improvements in the Absorbing and Stripping Process

By FRANK E. LICHTENTHAELER

IT may be safely stated that a sufficient supply of toluol will prove a prime factor in determining our success in the war. However manifest this may be, the plain fact that the supply is inadequate, and the immediate need of meeting the situation aggressively and in a well-directed manner, do not appear to be comprehended to the full extent demanded by the exigency. This does not fail to take account of existing plans for increasing the supply, but refers more directly to an observed tendency to think in terms of the present only; and if one may judge from information published to date, the main issue, an unfailing supply of toluol, is hopelessly obscured by repeated descriptions of some particular process and incidental apparatus without evidence of a clear understanding of basic principles involved, yet with an air of finality that does not seem warranted on any sound engineering ground. Unessential details have been painfully emphasized to the exclusion of the broad underlying facts that, after all, will determine the eventual degree of success. A comprehensive plan of procedure founded on a scientific analysis of the situation seems to be lacking.

War Requirements

It has been stated that 22,000,000 gallons of toluol must be forthcoming by September, 1918, to supply an army of one million men. It is conceded that ultimately we may have four or five million men in the field and presumably the toluol production must increase proportionately. Published figures seem to account for approximately 12,000,000 gallons in addition to the present output from coke ovens, most of the latter already being taken by the navy. Yet the strongest accompanying statement is that "it is interesting to note that this is more than half the amount required." The significant point escapes emphasis: Where, definitely, is the other half?

Our Government is developing a wonderful machine for the creation of a vast trained army, the all-sufficient power of which will insure victory and a real peace. An equally efficient machine must be developed simultaneously to supply the endless quantities of munitions and materials from which they are made, and at a rate far in excess of the army's immediate needs. This is the greatest task for those of us who stay behind, and if we fail we have betrayed our brave men who are going with complete confidence that we will do our part as they do theirs.

The undoubted urgency of these matters would seem to warrant a broad survey of the situation in the hope of arriving at some elastic plan of procedure capable of extension to meet demands far beyond to-day's limited vision. At a time of great stress it is inadvisable to attempt a nice calculation of quantities of essential supplies that are likely to be needed. Sound judgment warrants the assumption that ultimately we may have to provide ourselves and our Allies to an extent far exceeding all possible forecasts. Our plans, therefore, must contemplate a large excess of all essential materials. An overproduction will be forgiven as mere insurance, protecting present and future generations. A shortage will doom us to almost certain defeat and the shame of having failed those who go to bear the brunt of battle.

The purposes, then, of this article are threefold:

First: To warn against delay in providing an unlimited supply of toluol. All available resources, great and small, should be developed simultaneously, not gradually in order of their importance only as the need becomes more pressing. The estimated deficiency must come from new and undeveloped sources, such, for instance, as the cracking of petroleum in excess of the normal requirement for carburetting purposes; and there must be a liberal reserve anticipating the invariable error of underrating ultimate needs.

Second: To advocate more simple and economical methods of toluol production, that our financial and material resources may be conserved to the utmost. Specific recommendations along this line constitute the main subject matter of this article.

Third: To emphasize the costly mistake of our Allies, if we may judge from observations in Canada, in respect to wholesale waste of toluol in the process of munitions manufacture. If we can but bring ourselves to foresee the likelihood of a similar condition in our own munitions factories, much could be done in the way of remedying or preventing needless loss of this essential material and the incidental cost and labor attending its production.

Development of Resources

With this attempt to state the fundamental proposition and with a strong desire to contribute toward a more rational means of meeting its terms, we proceed directly to suggest specific recommendations in respect to improved methods of toluol production. Reviewing briefly the question of supply, there are three main sources usually referred to:

1. Coke-oven gases.
2. Illuminating gases.
3. Cracked petroleum products.

In respect to the first source, the utmost pressure should be brought to bear in the matter of new by-product coke-oven installations, including equipment for treating the gas and tar for maximum yield of toluol and benzol. These installations require considerable time, and the comparatively few available companies, experienced primarily in the intricacies of by-product oven construction, should have their efforts directed and concentrated on a rapid and unlimited development of this field. This alone constitutes a task, the accomplishment of which is of no less importance than the exten-

sive ship-building program of the United States Shipping Board. Certainly the experience and manufacturing capacity of these same concerns should be fully utilized in respect to recovery and refining apparatus required in connection with by-product oven installations. It should not be too quickly assumed, however, that their very creditable progress in respect to recovery methods and apparatus has reached the same high plane of development that applies to their work in connection with coke ovens. It stands to reason that other American concerns, who have made a life-work of solvent recovery and refining problems in the same sense that coke-oven manufacturers have specialized on coke-oven practice and with equivalent progress in the development of their knowledge and skill, may likewise have important contributions to offer pertaining to advance progress in recovery and refining methods not included in the usual scope of gas engineering and evidently unappreciated by specialists in coke-oven practice. We hope to show later that a very material improvement is possible along these lines—a highly desirable improvement if it helps to reduce the practice to one of greater simplicity and higher economy.

Turning next to the third source mentioned above, namely, cracked petroleum, we believe this will ultimately become of great importance. After all of the gas works have contributed their utmost, it will probably develop that the output alloted to by-product coke-oven plants cannot be increased with sufficient rapidity to span the gap, in which case it would appear necessary to turn to the cracking of petroleum, because considerable information is available on the subject and the necessary equipment could be provided within a comparatively short time. Certainly this possibility should be anticipated, and if the growing coke-oven supply cannot be depended upon except for remote needs, work should be started immediately along the lines of petroleum cracking, especially as this appears to be a source capable of unlimited development. In this connection it is desired to mention work done by the Standard Oil Company in producing benzol and toluol from California crude oils. It is our belief that developments in this quarter have passed beyond the experimental stage, making it possible perhaps to estimate a dependable future output. We have built apparatus for producing "toluol pure" from the crude light-oil mixtures resulting from cracking California oils, and sincerely believe that it is a field offering possibilities that cannot safely be overlooked.

Source two, above, namely illuminating gases, absorbs our main attention for the present, principally because it offers a large available supply that can be made to yield results most quickly. Besides it is realized that the carburetting of water-gas is essentially a petroleum cracking process, with the great advantage that hundreds of plants are available, requiring merely the addition of suitable recovery apparatus. This article deals mainly with the situation in respect to source two—the recovery of toluol from illuminating gases. We recommend a comprehensive and simultaneous recovery applying to carburetted water-gas, coal-gas and oil-gas, including their respective tars. The same procedure that we will suggest would apply also to sources one and three, above. This should be borne in mind in connection with a broad study of the entire situation with the purpose of simplifying and increasing the efficiency of recovery methods as applied to whatever source. That is to say, recommendations that may appear pertinent to illuminating-gas recovery methods might also be expected to improve the economy of recovery from oven gases and all other sources, as well.

The simultaneous working of all toluol-yielding sources, as suggested, raises the question of how to handle the many cases involving associated and inseparable paraffins in an excess of 2 per cent, which has been set as the limit above which the toluol is claimed to be unfit for explosive purposes. There stands against this claim, however, an equally authoritative statement to the effect that upward of 10 per cent inert paraffins does not interfere with subsequent nitration, at the same time suggesting the separation of the paraffins from the mono-nitro product by simple distillation. This latter claim may have been disproved, but we find no information to this effect. Is it not more likely to be a case of prejudice on the part of munitions manufacturers who have been long accustomed to insist on "toluol pure"? Now toluol containing 10 per cent of inert material is essentially "toluol pure," and it should be very definitely determined whether or not mere reluctance to add a simple and inexpensive distilling operation, coupled with characteristic bias in favor of antiquated methods, is the sole explanation and reason for casting aside a substantial amount of toluol that can ill be spared. The oft suggested plan to so carefully control the carburetting processes as to keep the paraffin production below 2 per cent would appear to be a far more difficult undertaking than minor modifications in the established practice of munitions manufacture.

The Absorbing and Stripping Process

It may not be amiss at this point to establish a reason for selecting the so-called "absorbing and stripping" process to the exclusion of other methods. We recommend this procedure notwithstanding the fact that we hold basic patents covering solvent recovery from gas mixtures by means of combined compression and refrigeration. This latter process is practically and extensively employed in connection with the recovery of gasoline from casing-head gas, and we might be supposed to have a prejudice in its favor. The "absorbing and stripping" process, however, lends itself in every way to existing conditions at gas plants throughout the country, and the same applies to by-product coke-oven installations and the few existing petroleum-cracking plants. The compression and refrigeration process, unfortunately, requires the use of very large and expensive compressors and expanding engines, and the procedure involved is so radically different, more difficult and dangerous than comes within the experience of the industries to be dealt with that every conceivable argument for employing this process appears to be disproved. So far as we know, there are no other practical methods that might be employed, so we are certainly justified in concentrating efforts on a general betterment of the so-called "absorbing and stripping" process.

We propose to treat this subject under four main headings, namely: Absorbing, Stripping, Concentrating and Refining. Part one of this article refers more particularly to improvements in absorbing and stripping, leaving discussion of the remaining two sub-divisions to be covered by part two to follow. This division of the

subject is suggested by the fact that all gas works will be interested in absorbing and stripping, but whether or not they will engage in concentrating and refining of the light oil is an important point in question which also we will leave for later discussion.

Lummus Absorption System

We have endeavored to conceive an ideal procedure and accompanying apparatus to fit existing conditions in both large and small plants, insuring maximum economy of production and least demand on the facilities, skill and financial resources of the gas manufacturer. In fact, this same problem under slightly different aspect was presented to us as far back as July, 1913, in connection with the recovery of wood alcohol from its vaporous mixture with the fixed gases of charcoal by-product ovens. We devised a method at that time which formed a nucleus for our subsequent development of the so-called Lummus system of recovering the condensable constituents of vapor-gas mixtures. The original conception was not put into practice because it represented a departure from usual methods employed at wood chemical plants and we were unable to overcome the prejudice in favor of long-established practice, although wasteful and illogical. However, more recent developments in connection with petroleum cracking gave us the much hoped for opportunity to crystallize our ideas on this subject and definitely design and build plants on a commercial scale.

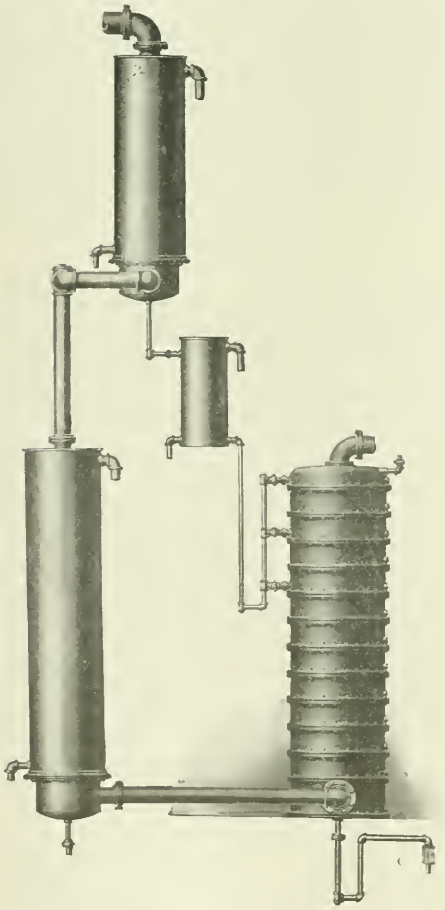


FIG. 1—ABSORPTION SYSTEM OF SOLVENT RECOVERY FROM FIXED GASES

Accompanying Fig. 1 illustrates the general arrangement of apparatus as employed in connection with the Lummus absorption system of solvent recovery from fixed gases (patent pending). Briefly, the method consists in scrubbing a residual gas-vapor mixture by means of a high-boiling condensate that has been previously removed from the initial gas-vapor mixture. The operation is described as follows:

The initial gas-vapor mixture, whether it be coke-oven gas, illuminating gas or the products of cracked petroleum, is led into a condenser, shown at the top of Fig. 1, in which partial condensation is effected, limited principally to the higher boiling constituents. This condensate is cooled in the cooler, shown directly below the primary condenser, and then admitted to the top of the absorber or scrubber, shown at right. The residual gas-vapor mixture, issuing from the primary condenser, is thoroughly cooled in the large cooler shown at left, from which it passes into the base of the scrubber, within which it is caused to bubble repeatedly and in counter-current fashion through seals flooded from above with the cold high-boiling condensate, as previously described. It is at once obvious that the scrubbing or absorbing operation is in all essential respects the same as that commonly employed in all absorbing operations. We strongly recommend a type of absorber that insures positive counter-current contact between gas and absorbent, instead of the "hurdle" type of absorber, which permits of surface action only, thereby requiring an excessive amount of absorbent and an absurdly large superficial area. However, this important distinction will be discussed later in greater detail, the main point to be emphasized here being the novel feature of the system described, whch consists in the use of the higher-boiling constituents of the initial gas-vapor mixture as the ideal absorbing medium. It directly follows that the use of this available absorbing medium removes the need of an external petroleum or tar-oil absorbent, and incidentally eliminates the many troublesome and inherent difficulties common to the repeated use of such absorbents.

Tar as Ideal Absorbing Medium

It will be immediately realized that the gas-vapor-tar combination, common to all methods of illuminating-gas manufacture as well as to by-product coke-ovens and petroleum-cracking processes, directly lends itself to the same method of gas treatment described above. In the case of the gas works, the partly purified gas from which toluol is to be recovered has already been largely relieved of its burden of tar, the latter constituting the high-boiling portion of the initial gas-vapor mixture. This tar is none the less available as the ideal scrubbing medium for the residual, toluol-bearing, gas-vapor mixture, and it may be so used with many obvious advantages if certain simple conditions be complied with. Furthermore, the use of tar as the scrubbing medium has long since been removed from the

realm of mere theory and experimentation. The so-called Carpenter process, as successfully employed throughout Great Britain, according to best obtainable information, refers to the identical procedure that we here recommend and which, as stated, we have been using successfully in connection with the products of cracked petroleum and originally conceived by us in the summer of 1913. We therefore feel that we are not offering an untried process, and trust that the many advantages of this method of procedure will at least claim the attention and careful investigation of our Government officials who have in hand this important problem of intensive toluol production.

Accompanying Fig. 2 illustrates diagrammatically our proposed absorbing and stripping system, using tar originally contained in the gas as the ideal absorbing medium to remove toluol from the residual gas mixture.

The various steps involved in the operation consist in warming and dehydrating the tar, cooling the tar to 60 deg. Fahr. or lower, and then causing positive counter-current contact between the cold tar and the cold gas in a suitable absorber. The "benzolized" tar issuing from the absorber is finally treated in a continuous stripping still, in order to remove the total light-oil fraction comprising the portion recovered from the gas and also that originally present in the tar as well.

Condensers and heat interchangers are employed, as indicated, to improve economy in respect to heat consumption. The residual tar, free of its light-oil content, emerges from the process and is available for use as road binder or for other purposes as special conditions may determine.

Distinctive Features of the Lummus System

The following distinctive features of the above process should be especially noted: In the first place, tar which is already available at all plants constitutes the scrubbing medium, and thus obviates the necessity of employing a foreign absorbing oil. In the second place, the tar absorbent makes but one passage through the system. The repeated use of the absorbing medium, common to other processes recently suggested, is thus avoided, as well as the constant re-standardization of the absorbing medium and repeated treatments for removal of naphthalene, which in the case of the cyclic system otherwise soon renders the oil unfit for absorbing purposes.

Centrifugal Tar Dehydration

Careful dehydration of the tar is essential to insure high absorptive efficiency. In our opinion the dehydrating operation can be performed most economically by means of the centrifuge. It appears that even water-gas tar may be dehydrated in this manner if heated to approximately 80 deg. C. in order to obtain a favorable difference in gravity between the water and tar. Lunge describes this method of tar dehydration and mentions an observed cost in the neighborhood of 25 cents per ton. We have confirmed Lunge's assuring statements in respect to centrifugal dehydration and incidental cost of operation by discussions with American centrifuge manufacturers, and find that at least three reputable American concerns are familiar with the problem and are ready to build the special form of centrifuge required. One concern was prepared to state the cost of centrifugal dehydration of coal tar, calculated from test runs, at 44 cents per ton, based on a tar emulsion containing as high as 50 per cent of water. We had previously corrected Lunge's figure to 50 cents a ton, allowing for present abnormal cost of power and labor. In this connection it is interesting to note that two of the concerns referred to have experimental departments, suggesting the desirable possibility of submitting to them samples of tar as produced by

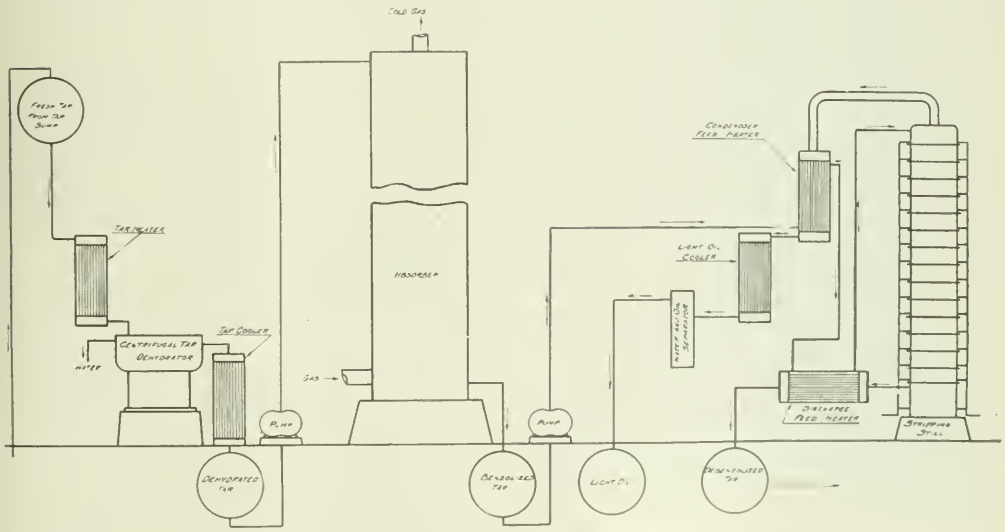


FIG. 2. ABSORBING AND STRIPPING SYSTEM

different gas works, in order that the best conditions for centrifugal dehydration could be determined for each particular case.

The "Cap-and-Seal" Absorber

In respect to absorbing apparatus, we strongly recommend the so-called "bubble" or "cap-and-seal" type. Accompanying Fig. 3 illustrates one arrangement of this type of absorber successfully employed by us for years past in connection with various solvent-recovery undertakings. The main arguments in favor of this type, as opposed to the "hurdle" type of absorber, are:

(1) The definite relation made possible between the quantity of absorbing medium used and the volume of gas to be scrubbed.

(2) The positive and repeated contacts assured between gas and absorbing medium.

This is to say, the "cap-and-seal" arrangement permits of admitting the exact amount of absorbing medium required to remove satisfactorily the volatile constituents of the gas in a single passage through the apparatus, which, together with the intimate contact caused between gas and absorbing medium, insures the utmost economy of operation. In the case of the "hurdle" tower, absorption is entirely dependent on surface contact, the ineffectiveness of which is clearly demonstrated by the tremendous amount of surface made necessary, requiring towers 60 to 75 feet in height, and in most cases using two such towers connected in series. Furthermore, the "hurdle" tower requires thorough wetting of all the surfaces, which can be accomplished only by extravagant use of absorbing oil, out of all proportion to the amount required for actual absorption. This means not only a large and useless investment in absorbing oil, when employing a foreign oil, but the cost of pumping this excessive amount of oil repeatedly to the extreme heights mentioned is an item of expense that does not seem to be entirely justified.

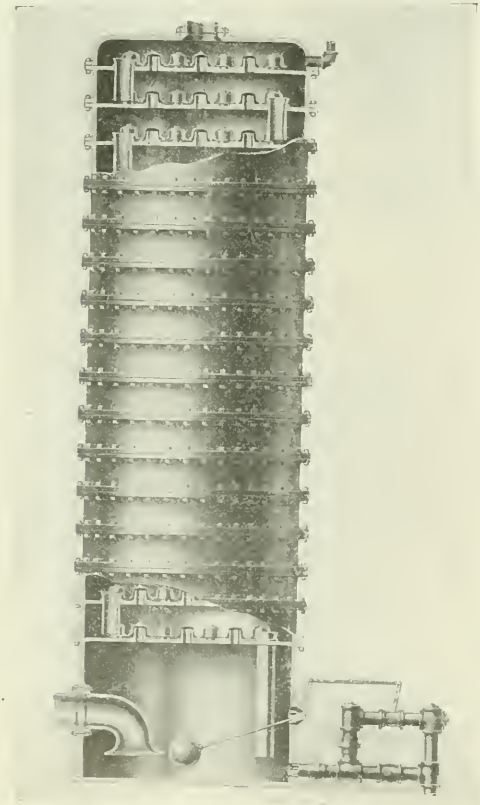


FIG. 3. CAP-AND-SEAL ABSORBER

Following is a striking illustration of the very satisfactory results obtainable with "bell-and-seal" absorbers as compared to towers filled with packing material for surface absorption such as the "hurdle" type. A prominent American concern recently desired to recover alcohol, acetone, etc., from the air-vapor mixture of these solvents, formerly wasted from an important drying operation. They first tried tall towers 25 or 30 feet in height and 4 feet in diameter, filled with packing material for surface absorption, using cold water as the absorbing medium. The results obtained were discouraging poor, indicating the need of much higher towers and an excessive amount of water to thoroughly wet the surfaces. We advocated a "bell-and-seal" absorber as being cheaper and far more efficient, and later installed a seven-tray absorber of the "bell-and-seal" type, measuring 24 in. square and standing about 5 feet high, equipped with Lummus patent atomizing caps. This small absorber effected practically complete recovery from the same volume of air and under the same conditions that previously applied to the rejected surface absorber. Water was used as the absorbing medium in the case referred to. It stands to reason, however, that exactly the same conditions apply, whatever the gas-vapor mixture or absorbing medium may be. Just as crude distilling colums, depending only on surface contact, have been largely abandoned in favor of "cap-and-seal" columns, so we believe will "hurdle" towers be abandoned eventually, for the more efficient and compact absorbers, and for quite similar and fundamental reasons.

Though we have no definite information as to close costs of "hurdle" towers, we are rather confident that their equivalent in the shape of "bell-and-seal" towers, in view of the limited number of trays or decks required, are no more expensive, at the same time offering the advantages cited, namely, while positive contact and minimum quantity of absorbing oil, with consequent economy in respect to the amount of absorbent required and the reduced cost of pumping.

Returning to our process, involving the use of tar as the scrubbing medium, it becomes very essential to use some efficient form of absorber, such as suggested above, for the obvious reason that an unlimited amount of tar per plant is not available. However, the quantity naturally produced has been shown by Dr. Carpenter, and demonstrated by English practice, to be sufficient for scrubbing the accompanying quantity of gas. Its use entirely eliminates the otherwise necessary investment in absorbing oil, which we understand costs in the neighborhood of 10 cents a gallon. Even the conservatly stated wash-oil requirement of 10 gallons per 1000 cubic feet of gas represents a considerable investment, especially when it is remembered that a large surplus

is required and frequent replacements are necessary to balance unavoidable losses.

We have designed a very simple form of absorber, which retains all the advantageous features of the "bell-and-seal" type, but excludes the rather expensive construction that usually applies to this type of tower. Our aim in this connection has been to develop an improved form of absorber, lending itself to economical construction throughout, so that even large sizes can be quickly made and without undue expense, at the same time entirely eliminating the intricate internal construction pertaining to hundreds of bells and seals required for the tower scrubber illustrated in Fig. 3. While we are not prepared to make positive claims in respect to this new type of scrubber, it appears, from estimates that we have been able to make, that it will be possible to reduce the cost of construction to less than one-half that applying to the usual "bell-and-seal" tower.

Advantages of Tar as the Absorbent

It may be well at this point to group some of the more obvious advantages applying to the use of tar as the absorbing medium:

a—The investment incidental to the use of a foreign absorbing oil is eliminated. This constitutes an important saving, especially when it is remembered that in the commonly described cyclic operation, a large excess of absorbing oil must be kept in readiness to take the place of the portion withdrawn from the process for special treatment to remove the naphthalene.

b—The appreciable and unavoidable loss of absorbing oil, requiring periodic replacement, is prevented by the use of tar absorbent in the non-cyclic system as suggested.

c—The toluol content of the original tar is recovered, as well as the portion obtained from the gas, and this is accomplished with one application of heat, without additional apparatus or operations.

d—The accumulation of naphthalene and other objectionable heavy oils in the tar becomes of no consequence, because the tar is used but once. This removes the necessity of elaborate chemical control and periodic external treatment of the absorbent for removal of the naphthalene, etc.

e—Should it now or later be required to recover the carbolic oil present in the tar, this may be accomplished simultaneously with the stripping of the light oil. Other methods of procedure exclude the tar and therefore would require additional equipment and use of heat should the tar constituents become of great importance.

f—As large and small gas plants produce tar in proportion to their gas output, the process becomes applicable to plants of whatever size, and similar types of apparatus would apply to recovery from water-gas, as well as from coal-gas and all other sources.

g—The entire elimination of an external absorbing oil removes the serious situation that would result in the event of a shortage of "straw" or tar oils required for unlimited development of the cyclic "absorbing and stripping" process.

h—The light oil produced by the proposed process would not contain absorbing oil requiring separation and return to the cycle. Therefore this light oil could be shipped to a central refinery without involving loss of absorbing oil.

i—No shut-downs would occur, due to delayed shipments of absorbing oils. Elimination of any important dependence on overtaxed transportation facilities, except for out-going concentrates, is thus assured.

Lummus-Hirzel Stripping Still

Accompanying Fig. 4 illustrates the Lummus adaptation of the so-called Hirzel stripping still, employing high-pressure steam in closed coils for maintaining a required temperature within the still, and with superheated steam injected into the lower chamber of the apparatus to assist evaporation of the light oil by repeated contacts through the large bell seals, as shown. It hardly needs to be explained that the so-called "benzolized" tar is admitted to the top chamber of the still and is caused to flow downward from chamber to chamber, counter-current to the upward passage of steam and vapor bubbling through the bell seals. The vaporized light oil, together with steam, passes over to a condenser, in which the mixture is condensed and cooled, and the light oil subsequently separated by means of a gravity separator. The "de-benzolized" tar, as pre-

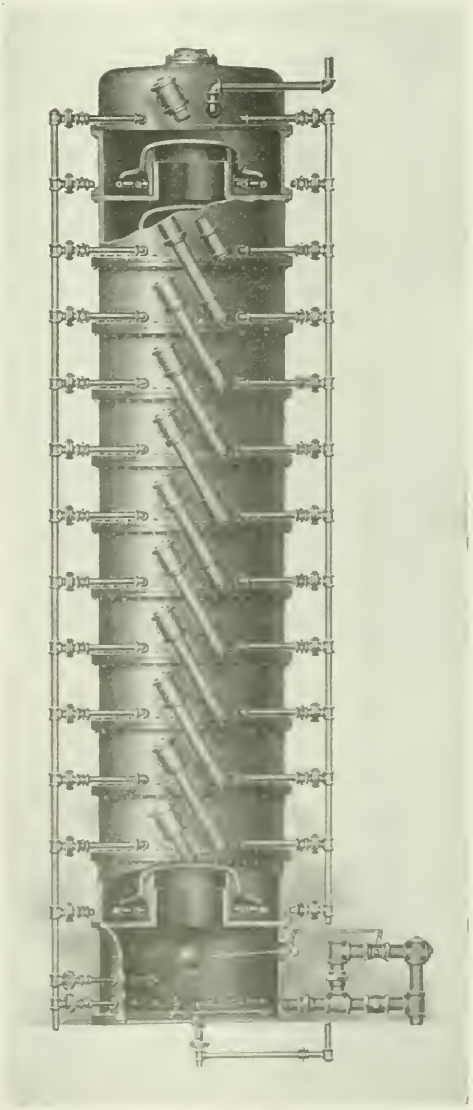


FIG. 4.—STRIPPING STILL

viously explained, issues from the lowest chamber of the still, and, after giving up its heat to the incoming "benzolized" tar, through a suitable heat interchanger, has completed its usefulness and is ready for sale or other disposal, as particular circumstances may determine.

Hirzel has quite properly pointed out that the above is not essentially a distilling operation, but rather one of separating a comparatively volatile body from one of low volatility by means of evaporation. On this account, a relatively constant temperature is maintained throughout the series of chambers, this being contrary to conditions favorable to true distillation, in which case the temperature decreases from the bottom toward the top of the column, corresponding to the rate of increasing the percentage of the low-boiling component in the ascending vapors. The Hirzel apparatus, therefore, is merely a convenient form of evaporator, for exposing the "benzolized" tar to heated surfaces simultaneously with repeated contacts with superheated steam and its associated light-oil vapor. Instead of placing pressure steam-coils within the respective chambers of the still, the tar may be superheated prior to its admission to the top chamber of the still. This procedure undoubtedly permits of simplifying construction somewhat, but has the disadvantage of being wasteful of steam. Under the most favorable conditions there is sure to be loss of superheat before the tar enters the column, and the temperature within the column must be maintained by an excessive use of steam injected at the bottom chamber. It is far more economical to supply the required superheat within and distributed throughout the column exactly at the points where it is needed. Furthermore, we have devised an improved design of the Hirzel type of still, simplified in respect to construction without losing any of the desirable features mentioned.

Lummus Direct-Fired Stripping Evaporator

During the year 1913 we carried on experiments on a semi-commercial scale to ascertain the behavior of certain gas tars when subjected to continuous superheated-steam distillation for the removal of the light-oil fraction. The apparatus comprised a modification of the Hirzel internally steam-heated still, and test runs were made, using both coal and water-gas tars. The results obtained conclusively proved the practicability of handling tars in this manner as opposed to the usual American practice of using direct-fired batch stills. It was found possible to completely remove the light and heavy oils, leaving a hard residual pitch; and the troublesome boiling-over habit, common to all batch tar stills, was entirely eliminated. But unfortunately one great disadvantage presented itself in too prominent a manner to be overlooked. The consumption of steam, both as superheated steam and pressure steam within the coils, was so great as to affect seriously the possibility of an extensive application of this otherwise very satisfactory procedure. We call attention to our experience in this connection, as conditions applying to all steam stripping processes appear to be identical to those encountered by us in respect to continuous distillation of tar with steam. Under the most favorable conditions, employing all possible heat economizers, we still found that the excessive consumption of steam constituted an item of expense that will at least bear thoughtful investigation.

In view of the above, we have been led to devise a new type of stripping still, which includes all the advantages of continuous operation without requiring the use of an excessive amount of steam. Furthermore, the design finally arrived at is very simple as compared to the Hirzel still and promises to be comparatively inexpensive. Accompanying Fig. 5 illustrates in a general way the arrangement of apparatus suggested. The "benzolized" tar, admitted at *A*, is made to flow in a very shallow stream throughout the length of the horizontal direct-fire-heated evaporator, as shown. Vertical diaphragms, with openings at alternate sides, are used to prolong the path of the tar over the heated surface. The "de-benzolized" tar issues at *B*, the sensible heat of which is utilized in warming the "benzolized" tar prior to its entrance into the evaporator at *A*. The residual tar, free of light oil, has thus, as before stated, served its entire useful purpose, so far as the recovery of toluol is concerned. Note that the "benzolized" tar enters at

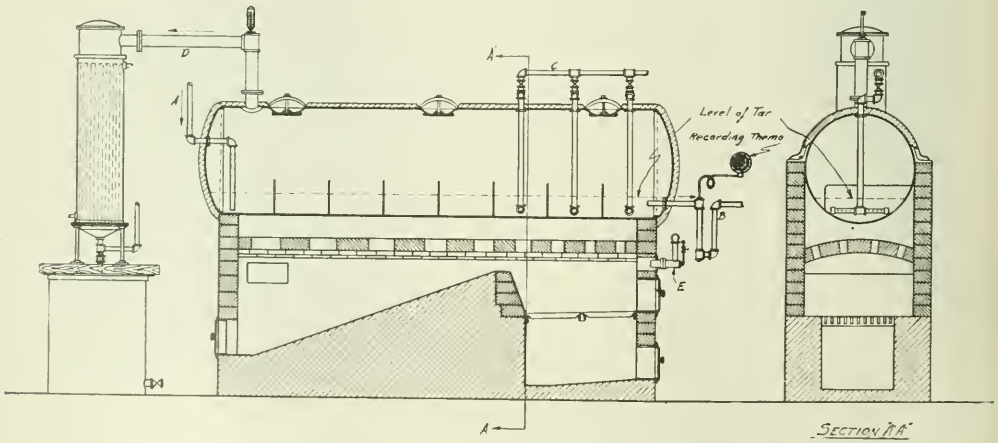


FIG. 5. DIRECT-FIRED CONTINUOUS STRIPPING EVAPORATOR

the cool end of the evaporator and the "de-benzolized" tar leaves at the hot end, with consequent counter-current advantages. Pipes marked *C* indicate means for injecting live superheated steam in the last three compartments, as possibly required in the event of desiring to remove the heavy as well as the light oils from the tar. The light-oil vapors pass through *D* to the condenser, to be condensed and cooled, ready for subsequent toluol concentration and refining. The evaporator may be heated by means of a coke fire used in conjunction with a tar burner, to permit reasonable regulation of temperature to avoid coking the tar. Should it appear desirable in some cases to operate at favorable low temperatures, a vacuum may be maintained within the evaporator by means of a vacuum pump attached to the outlet of the condenser. The small amount of steam required to operate the vacuum pump would not be of serious consequence. However, even this slight complication would not be required except perhaps in the event of carrying the evaporation to the point of producing a hard pitch.

Accompanying Fig. 6 illustrates the Lummus system of absorbing and stripping, the same in principle as indicated by Fig. 2, but substituting our direct-fired striping evaporator for the Hirzel type of steam-heated stripping still. In this case we do not attempt to utilize the heat of condensing the light-oil fraction, as the incidental saving does not seem to warrant the necessary apparatus complications. This apparent disregard of economy seems justifiable, due to the low cost of direct firing and the excess furnace heat available in spite of the most careful regulation of firing. On the other hand, the high pitch sensible heat of the residual tar is used for heating the incoming "benzolized" tar, as shown.

The apparent advantages of this direct-fired stripping evaporator may be enumerated as follows:

(a) The simple brick settings and inexpensive plate construction would seem to indicate a very low cost for this equipment as composed to that of the steam stripping stills.

(b) The total elimination of steam-heating and evaporating insures a marked reduction in operating expense, especially as coke and tar could be used as fuel.

(c) The convenient and easily understood operation is best adapted to labor conditions now obtaining at most gas works.

(d) Many boiler shops could turn out the evaporator shells quickly and in quantities. The Hirzel stills, involving castings and machine work, would prove a source of much more serious delay.

It must be admitted, in fact it is an assuring feature, that direct-fired continuous tar evaporators have been successfully employed in Europe. We are informed that their operation is simple and convenient, and results in respect to light-oil recovery are satisfactory. So again we merely suggest an improved form of apparatus that is not entirely new and untried in the sense of involving risk of unforeseen difficulties. Furthermore, we would not recommend the use of this still for "benzolized" straw-oil resulting from the cyclic process. The tendency to evaporate the lower-boiling portion of the absorbent would be, in our opinion, a serious objection, which, however, does not in any sense apply in the case of "benzolized" tar, which makes but one passage through the system.

Summary of Recommendations

Briefly summarizing the above article, we offer the following recommendations in the hope of stimulating, to whatever extent may be within our power and ability, an intensive toluol production:

a—The immediate organization of a Government-controlled and directed machine to develop a sufficient toluol supply with the same spirit and effect with which it is developing an army.

b—The prompt utilization of all available toluol sources and the simultaneous development of new sources to meet an ultimate requirement far beyond to-day's popular though erroneous conception.

c—More simple and efficient recovery methods and equipment, to conserve our limited resources against the possibility of a long and exhausting struggle.

d—Specific recommendations in respect to the "absorbing and stripping" process, including the use of tar as the ideal absorbent and more economical types of absorbers and stripping stills.

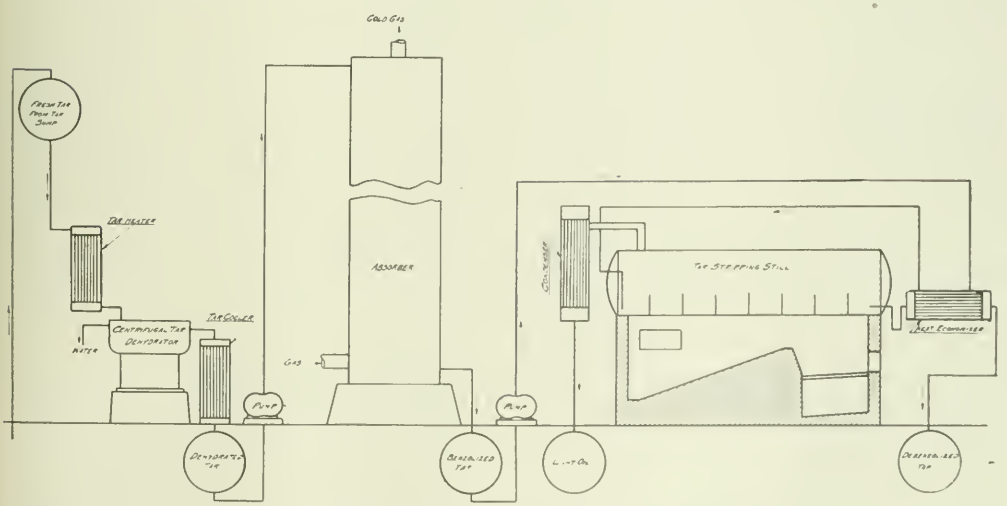


FIG. 6.—ABSORBING AND STRIPPING SYSTEM WITH DIRECT-FIRED EVAPORATOR

e—A thorough investigation of the real effect of the presence of paraffins on the manufacture of munitions, together with an educational campaign that may be required to overcome unfounded prejudice against paraffins.

f—Economical methods of munitions manufacture, especially to avoid waste of toluol, that the limited supply may be conserved to the utmost.

g—Finally, that there may be a country-wide awakening to the fact that our present insufficient toluol supply, unless quickly and effectively remedied, means defeat. This certainly is sufficient cause for grave concern, demanding utmost foresight and concerted, energetic action.

In conclusion, may we state that our recommendations, though intended to be highly practical and conservative, do not anticipate a hurried acceptance without careful preliminary investigation. The most we ask is a thorough consideration of our various suggestions, to be followed, if it appears warranted, by minor plant installations to definitely determine the degree of utility and dependableness of methods and equipment outlined. We also hope that sufficient publicity of our broader general plans may be realized for whatever good may result from our attempt to analyze existing conditions and to assist in stimulating a greater appreciation of the stupendous task that confronts us as a Nation.

It can hardly be said that we have taken ourselves too seriously. The occasion surely demands plain-spoken views and a pooling of experience and efforts, by which alone can we attain success. We recognize a duty in making known thus definitely such services as in our opinion we are best prepared to render.

The Walter E. Lummus Co.
Boston, Mass.

Synopsis of Recent Metallurgical and Chemical Literature

Temperature of Liquid Steel.—At the November meeting of the Faraday Society, in London, Mr. COSMO JOHNS spoke on "The Determination of the Temperature of Liquid Steel Under Industrial Conditions." Pointing out that skilled observers, with the aid of blue glass, were able to distinguish differences of 15 deg. C. when steel was flowing into a ladle, and that observers watching the same steel running into the ingot mold could distinguish temperature differences of about 10 deg. apparent, it was clear that any system of pyrometry to justify adoption must be able to record apparent temperatures with 5 deg. ± as the permissible variations. The system adopted, after much preliminary work, was the use of optical pyrometers using monochromatic light, and these had now been used in regular works practice for nearly four years. It was concluded as a result of this experience that concordant results of the required degree of accuracy required carefully trained observers, and the adoption of standard conditions of observation. Casual observers without knowledge of the many sources of error might easily obtain readings which departed 50 deg. from a correct reading. Observations must be made on the windward side of a launder down which steel was flowing from the furnace. If a value for the average temperature of that particular cast of steel was required, in order to determine its variation from the "normal" adopted for that particular practice, an observation of the center of the exposed side of the stream as it falls over the open end of the launder into the ladle when half the contents of the furnace had run out gave the best results. Such streams gave small but consistently different readings at the top, middle and bottom of the exposed side. The stream as it issues from the furnace taphole rises regularly in temperature as the successively hotter layers run out. The slag follows the same rule, but though serial readings obtained near the taphole have given much information as to the temperature gradient within the bath in the open-hearth furnace, it has not been found possible so far to explore the extreme ends of the gradient. That it is extremely steep near the surface of the bath is very probable, from the fact that it is in contact with the intensely hot flame of the furnace, and from the fact that under very favorable conditions the purest quartz sand has been fused, when floated on the surface of the bath, to a viscous fluid. Only "clean" surfaces of steel, free from oxide films, are suitable for observation, and these must of necessity be either rising in temperature, if flowing from the furnace, or falling in temperature if it is flowing from the casting ladle. Any temperature determination of liquid steel in open-hearth practice possesses no significance unless the relative time at which the observation was made is recorded. Owing to the importance of determining the softening or fusion range of the refractories, observations were made on the temperature of the interior of the furnace walls. As it was impossible to secure "black body" conditions, care was taken that the surfaces observed were "free radiators." These observations were therefore made after the furnace had been tapped. The gas was shut off and the door through which the pyrometer was sighted was lifted until wide open. Under these conditions every detail inside the furnace was visible: the joints in the brickwork, the junction of the sand banks with the side walls, port openings and places where wear had occurred, could all be perceived. Patches of new bricks could easily be distinguished from the adjoining old brickwork owing to their higher emissivity, though obviously at the same real temperature. It was suggested that if the emissivity of new silica bricks could be experimentally determined at 1650 deg. C. a very useful datum point would be available from which the emissivities of the surface of the slag and the seasoned bricks could be calculated. The emissivities adopted are tentative, and merely represent what best accords with the facts. Pyrometer readings of steel flowing from the ladle into an intermediate trough into the molds are tabulated, and the effect of oxide films with their higher emissivity is clearly indicated. It is concluded that under exceptionally favorable conditions a trained observer can repeat his readings with a variation of 2.5 deg. ± apparent while the variations in the observations discussed in the communication are something better than 5 deg. ±.

Hardening of High-Speed Steels.—At the November meeting of the Faraday Society in London, Prof. J. O. ARNOLD (University of Sheffield) spoke on "Pyrometry Applied to the Hardening of High-Speed Steels." He said the advantage of pyrometrically controlling the hardening of high-speed steel was a matter of common knowledge, and the most usual and best average temperature was 1300 deg. C. The practice at Sheffield University was to immerse the tool to be hardened in a

bath of fused barium chloride melted by a current which passed through two iron electrodes. This secured perfect regularity of temperature. The tools were then quenched in air, oil, or water.

Experiments were described in which five different pyrometers were used simultaneously; the Féry thermoelectric radiation pyrometer, the Féry bi-metallic spiral spring pyrometer, the Foster base-metal thermocouple, a modified Wanner radiation pyrometer, and the Mésure and Nouel, which Dr. Arnold favored very much, but in which the personal element was important. Using these different instruments and employing different observers, a grand mean temperature of 1296 deg. C. was arrived at, which was a tribute to the accuracy and reliability of the various methods of getting good observations. Dr. Arnold concluded by describing some observations that he had made on the casting temperature of steel tapped from an open-hearth furnace. The evidence of the results showed that such observations could be made reliable.

Potash from Feldspar.—In the Bulletin of the Institution of Mining and Metallurgy, Dec. 13, 1917, E. A. Ashcroft describes experiments on the production of potash from feldspar by an interesting method. He has worked out an industrial process and gives cost figures. In the process, orthoclase or microcline feldspar is dry crushed to 100 mesh (I.M.M.) in an iron mill and mixed with its own weight of pure dry common salt and then heated to 900-1000 deg. C. for two hours out of contact with air or moisture, or furnace gases carrying such air or moisture.

The sodium base of the salt displaces the potassium base of the feldspar strictly according to the equation:

$$2NaCl + K_2OAl_2O_3(SiO_2)_4 = Na_2OAl_2O_3(SiO_2)_4 + 2KCl.$$

If the temperature has not exceeded 1000 deg. C., and if moisture and air have been carefully excluded, the author states that the product will be found to consist of finely divided insoluble sodium feldspar (albite) and a mixture of quite neutral and freely soluble sodium and potassium chlorides. These chlorides may be readily lixiviated in water and are easily separated from each other by fractional crystallization.

The extraction of potash obtainable by this means from a sample of feldspar carrying upwards of 10 per cent K_2O will be in the neighborhood of 85 per cent under the conditions above stated. There is no loss by volatilization, and the weights of residue and salt will be found to correspond with the equation.

The experiment can be carried out in a large porcelain crucible (covered), or equally well in a sealed iron or nickel receptacle. Metals are not attacked so long as air and moisture are absent. These containers may be heated in an ordinary assay muffle for the experiment. If metal containers are used, it will be found that only on the outside of the vessel is there any attack, and this is due to air in the muffle. If air and moisture are excluded from the muffle, and a reducing or inert gas substituted, the containers will be very durable.

The author has independently discovered and studied this reaction, but he gives credit of priority for the discovery of the displacement of potash by soda obtained from salt to E. Bassett, who in 1913 patented in the United States and Canada a process based on the same reaction. The author has found that Bassett overlooked the necessity of excluding air and moisture. The author recommends the following as an emergency outfit: A standard bench of large "D"-shaped gas retorts (having 8 retorts to the panel and 10 panels, each panel having its own producer), and all the retorts inverted and provided with new metal end pieces of simple design. The whole furnace outfit is complete for no less than 50 tons potassium muriate of 80 per cent quality per day. That is as much potash as can be recovered from all the 300 blast furnaces in England put together, and assuming all that source of potash to be made available by means of expensive equipments of fume collectors and precipitators.

The author estimates that in normal times the 80 per cent salt will not cost 7*l.* per ton and not more than 15*l.* to 20*l.* even under war conditions. He says that any potash process with feldspar as raw material, if it is to be successful on an extensive scale, must stand or fall by a single product.

The whole problem then changes its aspect from a hopelessly complicated to a very simple economic problem, easily comparable with any simple mining venture.

The desirata for such an undertaking may be stated thus:

(1) Raw material in extensive deposits which can be quarried cheaply.

(2) Reasonably high and uniform potash content of feldspar.

(3) Water-borne freights for supplies to and from quarries.

(4) A simple and cheap process with reduction works on the quarry sites and not consuming acids or any other expensive materials.

All these desiderata are realized in the extensive deposits in Sutherlandshire, and, no doubt, they can be realized quite as favorably in many other parts of the world, in selected localities, if the same simple aims are kept in view, and the principles and process described are applied.

In New Zealand, in Australia, in Canada, and in parts of the United States, in Portugal, in Italy, and in other places there are favorable deposits of pegmatite feldspars, which lead me to anticipate that this source of potash supply may yet fill a large part of the world's requirements.

All consideration of by-products in such schemes should be a secondary thought, and should not form an essential part of the scheme. The author does not doubt that in some cases the treated feldspar may find useful applications and so add to the returns, but it must not be depended on for the results of any such enterprises.

When Are Chemical Results Patentable.—An interesting discussion of a decision handed down by Judge R. E. Lewis in the Eighth Circuit Court of Appeals in Chicago was given in the Chicago Chemical Bulletin for December. The suit was between the Corona Chemical Company and the Latimer Chemical Company. The discussion was as follows:

"The judge has made the ruling that the every-day

knowledge of the chemist which may prompt the execution of a successful experiment is not inventive genius. That the raising of the efficiency in degree only of any process without the accomplishment of any new function (if this efficiency is brought about by common knowledge of the chemist, his shop practice), this improvement is not patentable. This raises for the chemist the whole problem of what constituted new and useful improvement in the art of chemistry. In other words, what is a patentable invention in chemistry? This matter is of very great importance at the present time, because it is obvious that the whole subject is not clearly defined for the courts of America, and it is surely in the interest of chemists generally to define invention or discovery of a patentable nature in the chemical art rather than to require this definition at the hands of our American judiciary. Why not define it now rather than leave the matter in the hands of the lawyers and judges of our country and have forced upon us definitions, ruling limitations which may be troublesome or even disastrous to our fraternity?

Recent Metallurgical and Chemical Patents

Production of Oxalic Acid.—A process for the production of oxalic acid is patented by C. T. THORSSELL and H. L. R. LUNDEN, of Gottenborg, Sweden. The process relates to the production of oxalic acid from sodium oxalate, which is mixed with sodium carbonate and a little caustic soda.

"Oxalic acid and sulphate of sodium are obtained from the oxalate of sodium when sulphuric acid is added to the mixture of the three first-mentioned salts, and the sodium carbonate and the caustic soda are also transformed into sulphate of sodium. But this cannot be carried out conveniently in one operation, as acid oxalate of sodium precipitates and to get this transformed into oxalic acid so great a surplus of sulphuric acid would be needed that all the sodium would be present in the form of acid sulphate and there would still be a surplus of free sulphuric acid.

"By dividing the reaction in two parts or stages of treatment it can, however, be carried out with the desired result. Thus in the first stage the oxalate of sodium is transformed into acid oxalate of sodium and neutral sodium sulphate, and the sodium carbonate and the caustic soda are also converted into neutral sodium sulphate by means of a solution containing acid sulphate of sodium and sulphuric acid, which solution may be conveniently obtained from the second stage of treatment, thus making the process a continuous one.

"In the second stage the obtained acid oxalate of sodium is treated with sulphuric acid, whereupon oxalic acid and a solution of acid sulphate of sodium are obtained together with sulphuric acid, which may be used in the first stage of the repeated operation for the solution of the oxalate. Thus, in the first stage a solution obtainable from a previous stage and a solid substance (from the oxalate furnaces) are used, and a solution (neutral sulphate, forming the finished article) and a solid substance for subsequent use in the second stage are obtained. At the second stage a liquid (sulphuric acid) and a solid substance from the first stage are used, and a solution for subsequent use in the first stage, and a solid substance (oxalic acid=end product) are obtained.

"The finished oxalic acid must be washed with water and recrystallized so that it becomes perfectly pure, and besides it is advantageous to wash the acid oxalate a little, before it goes to the second stage. These washing liquids may be utilized without evaporation. The sulphate of sodium as well as the oxalic acid crystallize with water, and therefore a great quantity of water must be utilized in the operation. It is true that a little water is brought in with the sulphuric acid and that smaller quantities are formed when the carbonate of sodium and the caustic soda are converted into sulphate, but still the greater part must be added in the form of washing liquids. The method of working is thus made a little more complicated. (1,251,938, Jan. 1, 1918.)

Extraction of Rosin and Turpentine.—Improvements in the extraction of rosin, turpentine and oils from resinous wood are patented by JOHN E. TEEPLE, of Montclair, N. J. They comprise a process of extraction from resinous wood such as lightwood, stumps, pine slabs, etc., wherein such wood is heated and treated for a time in simultaneous contact with water and with spirits of turpentine, both the water and the spirits of turpentine being at their joint boiling point (the boiling point of the mixture) and such heating being conducted without substantial escape of vapors and the contact being either with condensing liquids or with a mass of each liquid. The extracted matters are removed together with water and solvent; and the wood is steamed to recover adhering solvent. (1,252,058, Jan. 1, 1918.)

By-products from Mine Water.—WM. M. PARKIN of Pittsburgh, Pa., patents a process of treating mine water containing sulphuric acid and iron salts. Water issuing from mines and particularly coal mines is a weak but highly corrosive solution containing acid, and is detrimental to fish life as well as destructive to submerged metal work, such for example as tanks, pipes, etc. These mine waters generally contain considerable free sulphuric acid, together with more or less aluminium salts. According to the patent it is proposed to treat these mine waters with calcium carbonate, in amount sufficient to neutralize all the free acid and to react with most of the iron salts. A precipitate is formed containing basic iron sulphates which is separated from the remaining liquid and heated to a temperature between 179 and 338 deg. C. producing a finely divided pigment. (1,251,564, Jan. 1, 1918.)

Production of Sulphite Acid Liquor.—G. D. JENSSEN of New York City patents a system of producing sulphite acid liquor in which the function of the absorbing towers may be changed at will without affecting the efficiency of the operation, and in which the process is a continuous one. A diagram of the apparatus is shown in Fig. 1. The operation is described as follows:

"In operating the system with the tower 1 as a strong acid liquor tower, the traps 16, 20, 21 and 51 are closed, also the valves 24, 34, 37, 28 and 42, and the traps 12, 19, 22 and 50 are opened, also the valves 25, 33, 38, 43 29.

"The sulphuric dioxide gas flows into the pipe 13,

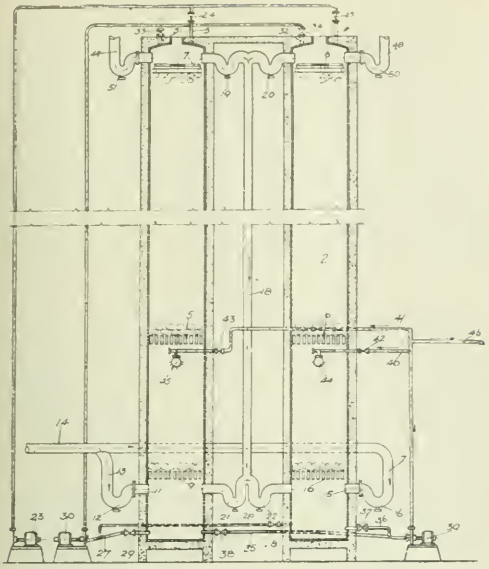


FIG. 1. DIAGRAM OF ACID SYSTEM

through the trap 12 and inlet pipe 11 to the tower 1 under the grate 9 and the tower 1 thus becomes part of the communicating passage from the gas plant for the initial and following flow of gas to the tower 2; which is the primary tower in the process of producing the acid liquor. The gas reaching the tower 1 rises in said tower through the blocks on the grate 9 and through the limestone pieces on the grate 5 and flows out of this tower through the trap 19 into the pipe 18 and down said pipe and through the trap 22 into the tower 2 under the grate 10 and rises in said tower 2 through the blocks on the grate 10 and limestone pieces on the grate 6 meeting the water being fed into the tower through the inlet pipe 4 as the said water trickles through the limestone and blocks. The spent gas exhausts through the trap 50 and pipe 48, being during the continuation of the process used in the two towers previous to its escape to the atmosphere.

"The weak acid liquor in the lower end of the primary tower is discharged through the pipe 26 to the acid liquor pump 30, from which it is forced up to the inlet pipe 31 and this weak acid liquor trickles down through the limestone pieces and blocks in the tower 1 and is met by the rising gas, which it largely absorbs, materially strengthening the acid liquor. The acid liquor flows out from the lower end of the tank 1 through the pipe 35 to the acid liquor pump 39, from which it is forced up to the pipes 41 and 46, a considerable quantity of the liquor flowing again into the tower 1 above the blocks and missing the limestone and thus apart from the latter absorbing the sulphur dioxide, so that the percentage of sulphur dioxide can be accurately gaged, this being regulated by the valve 43.

"To reverse the functions of the towers, 1 become the weak acid liquor tower and 2 the strong acid liquor tower, therefore the traps 16, 20, 21 and 51 are opened, also the valves 24, 34, 37, 28 and 42, and the traps 12, 19, 22 and 50 are closed, also the valves 25, 33, 38, 43, 29. Now the water is fed into the tower 1, and 2 becomes a communicating gas passage to tower 1 in the initial and following flow of gas thereto.

"The primary tower 1 receives its charge of gas from 2 which gas is absorbed by the trickling water and the weak acid liquor produced pumped into tower 2, from whence it flows to the acid pump 39 through the pipe 36 and from there it is pumped up to the pipes 40 and 46, the sulphur dioxide strength being regulated by the valve 42 as already explained.

"It will be seen that the process in certain parts follows out well known and practical knowledge in this art, but it also is a radical departure from common practice, as there is always an intervening tower between the sulphur dioxide plant and the primary tower and yet the towers may be reversed at will, thereby eliminating the necessity of shutting down the plant for washing the towers, as they are flushed regularly in use by the systematic change over of their functions. Then again each tower is provided with the means of regulating the percentage of sulphur dioxide, which may be used no matter how the towers are changed in regard to their functions and this is important both in the duplication of the parts and the novelty of the means employed. (1,251,533, Jan. 1, 1918).

Sulphur Dyes.—Two patents have been issued to Heinrich Heimann of Dessau, Germany, on sulphur dyes. The patents are assigned to the Actien Ges. für Anilin Fabrikation of Berlin. The first patent relates to the production of sulphur dyes by the action of sulphur on a mixture of an amino-, diameno-, nitrohydroxy-, and amino-azo compound with a C-alkylated diamine of the benzene and naphthalene series. One example of the process is given, as follows:

12 parts of meta-toluylenediamine, 20 parts of amino-azo-benzene and 80 parts of sulphur are heated together during about four hours upon say 180-230 deg. C. and then during about 1 to 2 hours to say 230-260 deg. C. The melt thus obtained is rendered soluble in the usual way by treating it with a concentrated solution of sodium sulphide. The new dye may be separated as usually for instance by introducing a current of air; it produces on unmordanted cotton in a dyebath containing an alkali metal sulphide beautiful olive shades which are fast to washing and to boiling diluted acids. (1,251,368, Dec. 25, 1917.) The second patent relates to the same class of dyes produced by the action of sulphur on a mixture of nitro-amino-azo compounds with a C-alkylated diamine of the aromatic series. An example follows:

16 parts of meta-toluylenediamine, 20 parts of para-nitrobenzene-azo-alpha-naphthylamine and 100 parts of sulphur are heated together to say 180-220 deg. C. during about 2-4 hours; the mass is then further heated during about 4-8 hours to say 220-260 deg. C. The melt may be treated as given above in order to obtain and purify the new dye which produces on unmordanted cotton a very beautiful yellow olive fast to washing and to diluted acid.

In a similar manner from a mixture of meta-toluylenediamine with para-nitrobenzene-azo-beta-naphthylamine a dye can be obtained which upon textile fiber produces a beautiful yellowish brown is likewise fast to washing and to boiling diluted acids. (1,251,368, Dec. 25, 1917.)

Baily Automatic Electric Furnace for Heat Treating Shells

The Electric Furnace Company of Alliance, Ohio, has developed an automatic furnace for heat treating high explosive and shrapnel shells. The furnace is an adaptation of equipments of similar size that have been used for some years in the heat treatment of steel railway and motor car parts. It combines the accurate temperature control of electric furnaces and the uniform quenching produced by the automatic manipulating device and eliminates almost entirely the manual handling of the shells. The makers state that the first cost is of course more than that of fuel-fired manually operated furnaces, but on contracts of any considerable size the labor saving and the elimination of rejections readily pay for the equipment.

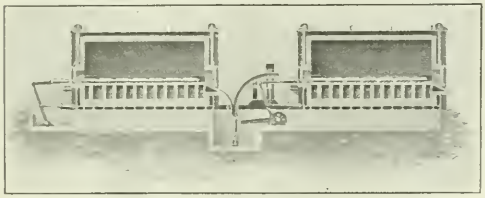


FIG. 1. CROSS SECTION OF TWO BAILY FURNACES WITH QUENCHING PIT

Fig. 1 shows a sectional view of two furnaces with a quenching mechanism located between them. The equipment includes a valve control pulpit and two contact-making pyrometers, one for each furnace. The couples of which are located in the discharge end of their respective furnaces, directly over the row of shells about to be discharged.

The operation of the equipment is as follows:

When the shells in the discharge end of the first furnace have reached the desired temperature, the heat from these shells actuates the pyrometer mechanism, closing a relay, and operating a solenoid on the radial dial switch of the pulpit, bringing the arm on the radial dial in contact with the switch, thus controlling the first movement of the equipment, which is the raising of the doors of the first furnace.

When the doors have been fully raised, the pusher on the first furnace pushes in the row of cold shells on the charging platform of that furnace, and, at the same time, pushes out of the discharge end the row of heated shells directly under the pyrometer tube. The pusher immediately reverses, and the doors close.

Meanwhile, the shells have dropped by gravity, nose down, on the quenching forks in the quenching pit, and immediately commence to rotate, the quenching water being turned on simultaneously and the shells sprayed from all directions, and internally.

At the same instant that the water is turned on, a time element, consisting of a disc operated by a constant speed motor through reduced gearing, is put in operation, and the water allowed to flow continuously for the predetermined time.

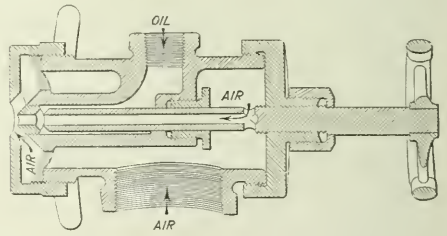
When the disk has made a complete circuit, the water is automatically shut off, the arms supporting the forks holding the shells move upward and deliver the shells in front of the pusher of the second furnace; the arms then return to their lower position ready to receive the next row of shells.

The quenched shells lie in front of the pusher of the second furnace until the shells in the discharge end of the second furnace actuate the pyrometer mechanism of that furnace, when a similar operation to the one described in connection with the first furnace takes place, pushing the quenching shells into the drawing furnace, and the drawn shells out at the discharge end. The only labor required is the placing of the shells on the charging platform of the first furnace, all other operations being performed automatically by the equipment itself.

A Fuel Oil Burner

In view of the difficulty of obtaining supplies of coal, attention is being turned in many quarters to other available fuels. In order to burn fuel oil it is necessary to have a burner, to atomize the oil and mix same with air. One type of fuel oil burner is shown in the accompanying illustration. It is known as the Coleman oil burner and is made by the Foundry Equipment Company of Cleveland, Ohio.

In this burner air is fed from the main air chamber through a hollow brass stem; the oil is fed around this circular stream of air, and at the end of the brass stem, which controls the oil supply, the oil is forced into the air stream at a sharp angle. This causes a breaking up of the oil into small particles and produces a primary mixing with the air. A second and larger



CROSS SECTION OF COLEMAN OIL BURNER

outer stream of air cutting through the primary mixture produces a further atomization and furnishes the proper combination of oil and air for complete combustion.

The burner was designed to overcome the clogging due to dirty and lumpy oil feeding through a small orifice. A quick means for clearing out any obstruction is provided by merely turning the hand wheel on the stem which opens the oil passage to full size.

The construction of the burner permits the feeding of a very small or large quantity of oil as well as complete control over the supply of air for combustion.

The burner connections provide for a ½-in. oil line and a 2-in. air line, giving a large range of feed of both oil and air. Air at 2 lb. and oil at 5 lb. per square inch are commonly used, but burners are in operation under a great variety of conditions as to pressure of oil and air.

The California Section of the American Chemical Society met on Jan. 12 in San Francisco and was addressed by Dr. Dorsey A. Lyon of the Bureau of Mines. J. W. Beckman is chairman of the Section.

Scrap Metal Briquetting Machines

A PATENT has recently been issued to Thomas Gilmore, Jr., of Brooklyn, N. Y., on a hydraulic briquetting machine for metal or mineral fines. The patent is assigned to the General Briquetting Co. of 25 Broad St., New York (1,247,667, Nov. 27, 1917). The machine is made by this company and is shown in the general view, Fig. 1. It is known as a horizontal three-stage briquetting press and is made especially for small capacities. It is a development of the Ronay system of metal briquetting which has been installed recently in many plants by the General Briquetting Co. The latter system is intended for larger plants where the output of scrap metal is over two tons per hour. The larger Ronay press is a vertical machine and is shown in Fig. 2. It will produce 6000 to 9600 lb. of briquettes per hour, of cast iron borings, 6-in. diameter and weighing 25 to 40 lb. each. On brass turnings it will produce 1500 to 7500 lb. per hour, the capacity varying with the density of the turning used for briquetting. Pressures from 23,000 to 33,000 lb. per square inch are applied on the briquettes.

The smaller horizontal type of machines, Fig. 1, have a cylindrical packing hopper provided with a swiveled lid. Material is introduced into the hopper intermittently. When the hopper is full the flow is checked and the lid closed, pressing the chips and curls together and getting rid of the surplus air. The operation of the low pressure pumps moves the plunger forward and packs the material into the mold shown at the right. The pressure is built up gradually, thereby allowing the escape of included air. Especial emphasis is laid on this feature.

When the material is thoroughly packed, the second stage begins. The full pressure is gradually built up until a maximum of 25,000 lb. per square inch is realized. A short interval is again allowed to assure permanent set. The pressure is removed. The third stage follows. By means of a lever the rear block of the mold is removed and a comparatively light pressure again applied. The plunge acts as an ejector and forces the finished briquette from the machine. The mold is closed, the plunger drawn back, the hopper opened and operation starts as before. This design is made in two sizes: "B" size, pressure 275 tons, making 6-in. briquettes, capacity $\frac{1}{2}$ to 1 ton per hour, and "C" size, pressure 125 tons, making 4-in. briquettes, capacity $\frac{1}{4}$ (and less) to $\frac{1}{2}$ ton per hour, depending in each case upon the nature of the material treated.

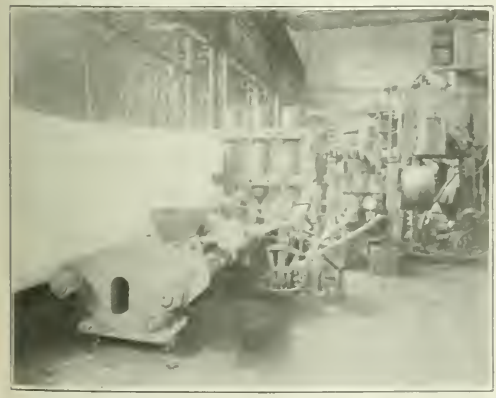


FIG. 1. TYPE "C" BRIQUETTING MACHINE

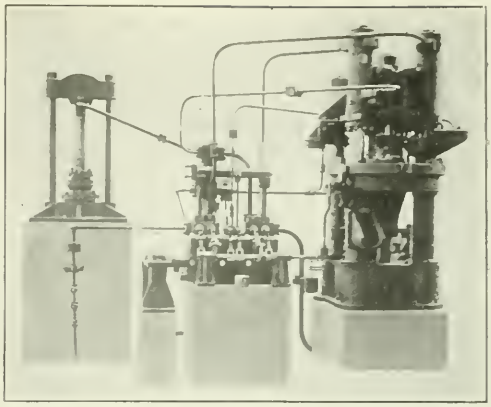


FIG. 2. TYPE "A" METAL BRIQUETTING PRESS, AUTOMATIC HYDRAULIC, SIX MOLD ROTARY PRESS

These presses have been used successfully on brass, aluminium, tin, zinc, lead, cast iron, steel, turnings and borings, sawdust, coal, coke, and various other residues and materials which were to be charged into a furnace. The use of fines in a furnace charge generally entails a heavy loss.

Bronze turnings when compressed into briquettes by this method only occupy one-sixth the original volume. When these briquettes are melted down a much smaller surface is exposed to the air, and the loss by oxidation is greatly reduced, as is also the time required for melting.

New Car Loader

A machine has recently been placed on the market by the Link-Belt Company, of Nicetown, Philadelphia, for loading all kinds of material into box cars. It is shown in the accompanying photograph.

It is a portable machine, driven by motor or gas engine, and handles the material delivered to it through the steel hopper, on a flat belt. On a recent

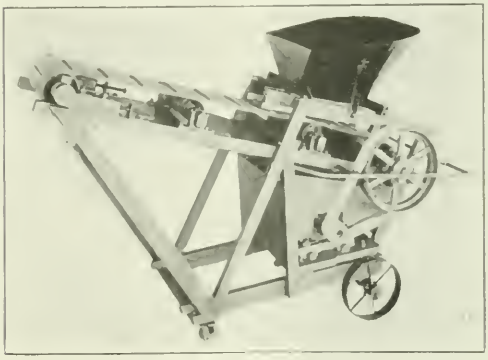


FIG. 1. NEW CAR LOADER

test it loaded 80 box cars in six days with two men. Its capacity is 80 to 100 tons per hour. In the present labor shortage the machine should prove especially valuable.

Personal

Professor WILDER D. BANCROFT of the department of chemistry of Cornell University, is in Washington, serving as technical adviser in the U. S. Bureau of Mines.

The following gentlemen have recently joined the staff of the Powdered Coal Engineering & Equipment Co., Chicago, Ill.; A. N. DETWEILER, consulting engineer; ALEX. L. FEILD, formerly assistant metallurgist at the Lake Superior Station of the Bureau of Mines; W. G. WILCOX, formerly superintendent of the Massena Works of the Aluminum Co. of America.

Dr. W. L. EVANS, a captain in the ordnance department, is organizing a large staff for research work and routine tests in the war department.

Dr. I. W. E. GLATTFELD has been appointed a member of the committee on the supply of organic chemicals for research during the war.

Dr. W. J. LENZ has severed his connection with the Lenz Apparatus Co., Inc., of 9 E. 16th St., New York, in order to devote his time to his manufacturing interests.

Prof. CHARLES E. LOCKE, professor of mining at Massachusetts Institute of Technology, has been appointed to give a course of 45 mining lectures during the last three weeks of January at the Missouri School of Mines, Prof. CARROLL R. FORBES of the latter school having entered military service.

Mr. F. C. NEWTON has resigned as general manager of the Newton Mfg. Company and is now assistant to the general manager of the U. S. Cartridge Company, at Lowell, Mass.

Mr. F. M. NOURSE has joined the advertising department of the Cutler-Hammer Mfg. Co. of Milwaukee in the capacity of technical writer. Mr. Nourse is a graduate of the University of Illinois, 1912, since which time he has been engaged in various branches of engineering work.

Professor W. A. NOYES spoke on the subject "The Development of a Career of Research" before the University of Illinois Section of the American Chemical Society on Jan. 15.

Mr. JOHN F. QUEENY, president of the Monsanto Chemical Company, 1800 South Second Street, St. Louis, Mo., has been elected general manager of the East St. Louis plant of the Commercial Acid Company, to succeed WILLIAM H. COOKE, the president, who has been called away to military service of the United States. The Commercial Acid Company is supplying the government with a large order of medical products.

United States Fuel Administrator Harry A. Garfield has announced the appointment of M. L. REQUA of California to handle oil matters for the United States Fuel Administration. Mr. Requa will have full charge of the activities of the Fuel Administration in connection with oil under the direction of Fuel Administrator Garfield. Since the organization of the United States Food Administration, Mr. Requa has been an assistant to Food Administrator Herbert Hoover. His transfer has been arranged with Mr. Hoover, who has consented to the change because of Mr. Requa's qualifications for his new position.

Mr. GUY E. TRIPP of New York, heretofore chairman of the Westinghouse Electric and Manufacturing Company, has been appointed by the War Department as Chief of the Production Division of the Ordnance Department, intrusted with the task of supervising and stimulating the production of all ordnance supplies. He has been given a commission as Colonel.

Dr. CHARLES H. VIOL, director of the Radium Research Laboratory of the Standard Chemical Co. of Pittsburgh, delivered an address on "Radium and Radio-activity" before the Philadelphia Section of the American Chemical Society on Jan. 17.

Mr. BURTON G. WOOD, formerly of the Monsanto Chemical Works of St. Louis, is now chief chemist of the Intravenons Products Co. of St. Louis, manufacturer of organic arsenic products, etc.

Mr. VICTOR YNGVE has been engaged as research chemist by the Oldbury Electro Chemical Company of Niagara Falls, N. Y., and will have charge of their research laboratory.

Prof. GEORGE J. YOUNG, recently professor of mining in the University of Minnesota, and previously in the Mackay School of Mines at Reno, Nev., has joined the editorial staff of the *Engineering and Mining Journal* as assistant editor-in-chief.

Current Market Reports

Chemical Market

Coal Tar Products.—The crudes for the most part have been quiet of late, but the intermediates have been in better demand than for some time heretofore. Prices in general are unchanged, although with an increased demand for the toluol intermediates, it would not be surprising to see a material increase in prices effective.

Benzol.—While there has been more business closed on contract over the year, there continues to be a good quantity of material offered at low prices. Spot material is not moving in large quantities, transactions in general being confined to small lots.

Toluol.—While a few producers of the intermediates have succeeded in securing releases of small quantities, there does not appear to be any inclination on the part of the authorities to grant general releases of material.

Naphthalene is in light supply; there has been quite a little business done during the past week with prices unchanged.

Benzoate of Soda supplies are light, and stocks for the most part are in speculative hands; prices are soaring by leaps and bounds. Only few producers are offering because of their inability to secure toluol.

Phenol.—There is but little available in the open market the Government having contracted for the majority of the output.

Aniline Oil.—A slightly improved inquiry, together with the scarcity of the necessary acids, has caused a slight advance in price.

Paranitraniline.—Some large sales have been consummated of late, but there continues to be large quantities offered and prices are unchanged.

Beta Naphthol.—There is a fair demand for the technical grade with prices varying but little because of the heavy production. Other grades are in light call and prices are on about the same parity as for some time past.

Aniline Salt.—There are a few offerings at a cent or two under the market, but the situation is quite firm on quantities of moment.

Metanitraniline.—Offerings are liberal and the demand light with prices unchanged.

Para Toluidine has been in better demand, but large factors have not as yet advanced prices, although it is said that some such plan is under way due to the toluol scarcity.

Ortho Toluidine.—Some large orders have been placed, but the price is unchanged.

Tolidin is in ample supply with the demand only fair and but little variation in the price range.

Anthracene is in light supply and large orders at goodly prices have failed to locate material quantities.

Para Nitro Phenol.—Large transactions have passed of late, but competition is keen and prices are unchanged.

Ortho Nitro Phenol continues to be the subject of inquiry from fur dyers and kindred lines, with prices firm.

Salicylic Acid has been more liberally produced, with the buying demand quiet and prices breaking considerably.

Diphenylamine has been in heavy demand, and but few are producing with prices advancing.

Para Amido Phenol has been produced liberally of late, competition is keen and prices have been reduced.

Heavy Chemicals.—The interval as is usual at this time of the year has been quiet but the extraordinary conditions that have prevailed this January have tended to create a still more uncertain condition. Transactions have mostly been for odd lots of material for prompt delivery. Contracts over the year have been neglected to a rather unusual degree. Improvement is looked for during the coming month as the middle of February is ordinarily the turning point.

Caustic Soda.—From the most speculative market in the chemical classification this market has assumed an aspect fully as quiet as any other chemical. Owing to freight difficulties sellers have been somewhat reluctant to quote forward positions but buyers have on the other hand shown but little desire to cover. Caustic soda is well held it is quite evident. Despite the lack of business prices have not declined and some material has commanded from 6½c up. Forward positions are generally obtainable at 6c.

Soda Ash.—This market has been more active than caustic but the total volume of business transpiring has not been very large. Stocks are well held and spot positions have generally commanded 3c., although the figure has been shaded a trifle from time to time. Export barrels have been in urgent request and it seems that export licenses have been granted probably to South American points.

Bichromate of Soda.—There has been a decided flurry in this market charged variously to speculative interests, and then, again, to an export order for some 250 tons concerning which there did not seem to be any definite information possible. In any event sales were rather frequent and passed as high as 20c. for spot. Producers seemingly thought the situation one that warranted higher prices for shipments from the works were advanced from 20c. and in some cases to 22c.

Bichromate of Potash.—In contrast this product has not been easily moved and there have been offers of spot material at 41c., although the general asking price is 43c. and 45c.

Calcium Carbide.—The demand continues far in excess of the supply, and sales, principally for export, are occurring at record high prices. The various sizes are selling at about the same price. Sales have occurred at high as 13½c. From 12½c. to 13½c. covers the market.

Acetic Acids.—The situation has revealed considerable firmness owing to the difficulty of securing raw materials, but there has not been a great deal of activity noted and consumers are rather inclined to hold off.

Cyanide of Soda.—The product has not moved well during the interval, and it has been possible to purchase prompt stocks at comparatively attractive figures. Generally regular sellers quote 43c. to 45c. as to shipping point.

Sulphuric Acid.—The acid situation continues to reveal the same degree of firmness previously noted, but there is not a great deal of activity noted. Some 66 degree brimstone acid has been offered at $40 sellers tanks works January shipment. In drums $45 is generally quoted. A lot of several hundred tons of 60 degree brimstone acid was offered at a New Jersey point at $40 drums for prompt shipment. Oleum has been offered at $75 prompt and $70 January shipment from works.

Nitric Acid.—So far there has been no pronounced movement in nitric acid. From various points there are offers of car quantities of the 42 degree material at 9c. The scarcity of carboys has tended to restrict shipment considerably.

Muriatic Acid.—Heavy government buying of late has created a very firm situation and prices are now much higher than any that have prevailed for a year. Carboys are so scarce that acid consumers have more difficulty in securing packages than the acid itself. Prices vary greatly according to seller and shipping point.

Bleaching Powder.—Slow train movements tend to restrict the market and at the same time tend to lower values. Bleach a month en route is not an attractive buy when fresh material is absolutely necessary. Shipments rolling have generally been available at about 2c. domestic drums but for prompt material from works producers have not been inclined to quote under 2½c.

The Iron and Steel Market

The weather has become the chief topic of conversation in iron and steel circles. The weather determines the volume of transportation and the iron and steel industry depends upon transportation. Fuel Administrator Garfield's order prohibiting the burning of fuel, with certain exceptions, Jan. 18 to 22, inclusive, and nine Mondays thereafter, created a furore in many manufacturing circles, but not in the iron and steel industry, where it was interpreted as a phase of the transportation situation. Some manufacturers stood aghast at the idea of their plants being closed by edict, but the iron and steel industry is used to strenuous things. Breaks in machinery that close plants are no less unexpected, individually, than was Dr. Garfield's order. It was obeyed by the steel industry as fully as physical conditions permitted.

The order was interpreted as permitting blast furnaces to operate, as they would be injured more or less by banking, and coke would be consumed without pig iron being produced, while the congestion in cars loaded with coke would simply be transferred from the neighborhood of production to the neighborhood of consumption. As to the steel-making units there was some question, but as a rule they closed. The rolling of steel ceased except as to exempted products. There was some accumulation of cold ingots, and a larger accumulation of Sunday metal, but there is no curtailment in the long run in the production of finished steel, for there is ample steel-making capacity to absorb the Sunday metal, and the ingots accumulated can be rolled in due course. As to the steel industry, the fuel order postponed the consumption of a great deal of fuel, but it did not effect a net reduction in the consumption. Rather there is in the long run an increase, by reason of the use of Sunday metal and cold ingots.

Transportation Governing Factor

More or less since late in November, 1916, and absolutely in the past few months the production of steel has hinged upon the production of pig iron, and the production of pig iron in turn has hinged upon the supply of coke, the chief restriction in the latter being the insufficient movement of the Connellsville product, next in order being a shortage of coal at by-product ovens. In any event it has been altogether a matter of transportation. Production of pig iron in 1916 was 39,400,000 tons, with several new furnaces completed during the year, and with still more new furnaces completed in 1917 the year's production was only about 38,600,000 tons. The production rate in December was about 34,000,000 tons, and the January rate has been still less. By this time the productive capacity must be close to and quite possibly in excess of 43,000,000 tons. The production of steel ingots in 1916 was 41,400,000 tons. The new capacity added in 1916 and 1917 is rated at over 8,000,000 tons, and could doubtless be counted upon for 7,500,000 tons in actual practice. That part of the 1916 production attributable to capacity in existence at the beginning of the year was fully 40,000,000 tons, hence capacity at the end of 1917 may be taken at 47,500,000 tons, but the monthly report of the American Iron and Steel Institute shows production in December, 1917, at the rate of only 37,000,000 tons. Production in January up to the time of the fuel order was at a still lower rate. All this restriction is shortage of pig iron, this in turn being shortage of coke and this in turn shortage of transportation.

The situation represents not a slight restriction but a great breakdown in the matter of transportation. Last year's coal production, almost adequate, was 544,000,000 net tons of bituminous coal and 100,000,000 net tons of anthracite, or 644,000,000 tons altogether. A liberal estimate is an average haul of 100 miles, since most industries have located close to their fuel. That is 65,000,000,000 ton-miles of freight movement, and in the five months ended last August the railroads conducted transportation at the rate of 425,000,000,000 ton-miles a year. The coal movement represents only 15 per cent of movement at last summer's rate, and under Government control, with various restrictions removed, the railroads are expected to do still better. Connellsville coke movement has lately been short by an average of about 75,000 tons a week, representing about 5,000,000,000 ton-miles of movement, or less than

one-eighth of one per cent of the railroads' normal capacity. The shortage of by-product coal represents probably a still smaller fraction.

The conditions described have been bad enough, but in recent weeks there has been the additional restriction of shortage of cars for moving finished steel, and then a large number of embargoes, with permits granted only occasionally. Despite the restriction in production caused by insufficiency of raw material, it has been impossible to ship the product, and finished steel has accumulated in warehouses and yards to such an extent that any considerable further accumulation is impossible, and departments are closing because they cannot ship their product.

In the circumstances there is no market to discuss and the trade thinks only of weather prospects. Steel shipments in January have represented only about half the capacity. With favorable weather, which cannot be many weeks distant, conditions may be entirely different. March is traditionally a record month for both pig-iron and steel production.

By Washington's edict of Dec. 29 the matter of iron and steel price revision will come up not later than March 31, but current events are manufacturing no testimony as to what should then be done. Cost of production at a time like this could not be used as a measure of what would be right prices in the future. One thing clear is that if Washington desires lower prices for pig iron and steel, the fair and efficient method of preparing the way is to seek first conditions that will permit orderly and economic production.

Non-Ferrous Metal Market

Friday, Jan. 25.—There has been very little activity in any of the markets during the past two weeks, and prices show little variation with the exception of tin which is still scarce and higher.

Copper.—The President has announced his approval of the recommendation of the War Industries Board that the maximum price for copper be continued at 23½ cents per pound f.o.b. New York until June 1, 1918. This price is subject to revision after June 1, 1918, upon the conditions, first, that the producers will not reduce the wages now being paid; second, that the producers will sell to the allies and to the public copper at the same price paid by the Government, and take the necessary measures under the direction of the War Industries Board for the distribution of the copper to prevent it from falling into the hands of speculators who would increase the price to the public; and, third, that the producers pledge themselves to exert every effort necessary to keep up the production of copper to the maximum of the past, so long as the war lasts. At the present writing it was difficult to buy electrolytic copper for February delivery. Casting copper is more freely offered. The jobbers' price remains at 24.67½ cents, New York.

Tin.—The tin market is unsettled and actual quotations are hard to give as no tin is offered for sale. The Emergency Fleet Corporation commandeered the pig tin stores in New York on Jan. 23, presumably for distribution to concerns having urgent need of the tin to finish war orders. The arrivals so far this month are only 1065 tons which is about one-fifth normal. England is still holding up shipping permits.

Lead.—The market has been very dull and the Trust price remains at 6.75 cents, with independents asking 7 cents. Very little metal is offered for sale. Transportation problems and the fact that some producers are sold up have combined to make the inactive market. Also, consumers are not bidding heavily.

Spelter.—There is not much to be said about the spelter market. Buyers do not show much interest and the market is very dull. The average quotation at New York now is about 7.82½ cents for Prime Western. Nothing has been done to fix prices on ordinary grades of spelter as yet and producers maintain that they cannot produce at a profit under 10 cents. The price on high grade spelter is adjusted by the Zinc Committee and War Industries Board.

Tungsten.—Scheelite has been offered more freely owing to arrivals from California and South America. Prices average about $24.50 for 65 per cent material.

Molybdenum.—The Canadian embargo on molybdenite has been raised and arrivals have been large, selling at $2.15 to $2.20 per pound for 85 per cent material.

Chromium.—Chrome ore is scarce and high prices are asked. Ferrochromium will probably go higher.

Quicksilver.—California material is offered at $130 per flask with Mexican at $125.

Other Metals

Aluminium, lb.	.36–.38
Bismuth, lb.	3.00–3.50
Cadmium, lb.	1.50
Nickel, electrolytic, lb.	.55
Silver, oz.	.87¾
Platinum, oz.	105.00
Palladium, oz.	130.00–135.00
Cobalt, lb.	3.25–3.50
Magnesium	2.00

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, JAN. 24, 1918

Acetic anhydride	lb.	Nominal	
Acetone, drums	lb.	Nominal	
Acid, acetic, 28 per cent	lb.	05½ —	.06
Acetic, 56 per cent	lb.	11¼ —	.12
Acetic, glacial, 99½ per cent, carboys	lb.	.34 —	.35
Boric, crystals	lb.	13¼ —	.14¼
Citric, crystals	lb.	75 —	.78
Hydrochloric, C. P	lb.	Nominal	
Hydrochloric, 20 deg	lb.	Nominal	
Hydrochloric, conc., 22 deg	lb.	Nominal	
Hydrofluoric, 30 per cent, in barrels	lb.	.06½ —	.06½
Lactic, 44 per cent	lb.	.15 —	.15½
Lactic, 22 per cent	lb.	.05½ —	.06½
Nitric, 36 deg	lb.	.09 —	.10
Nitric, 42 deg	lb.	.09 —	.10
Oxalic, crystals	lb.	.44 —	.45
Phosphoric, 47 per cent-50 per cent crude	lb.	.07 —	.07½
Phosphoric, ref. 50 per cent	lb.	.26 —	.....
Picric	lb.	Nominal	
Pyrogallic, resublimed	lb.	3.15 —	3.25
Sulphuric, 60 deg	ton	—	.....
Sulphuric, 66 deg	ton	40.00 —	45.00
Sulphuric, oleum (Fuming), tank cars	ton	70.00 —	80.00
Tannic, U. S. P., bulk	lb.	1.30 —	1.35
Tartaric, crystals	lb.	.78 —	.80
Tungstic, per lb. of W	lb.	1.80 —	1.90
Alcohol, sugar cane, 188 proof	gal.	5.05 —	5.25
Alcohol, wood, 95 per cent	gal.	1.35 —	.....
Alcohol, denatured, 180 proof	gal.	.78 —	.80
Alum, ammonia lump	lb.	04½ —	.05
Alum, chrome ammonium	lb.	.18 —	.19
Alum, chrome potassium	lb.	.23 —	.25
Alum, chrome sodium	lb.	12½ —	.13
Alum, potash lump	lb.	Nominal	
Aluminium sulphate, technical	lb.	.01½ —	.02
Aluminium sulphate, iron free	lb.	.02¾ —	.03
Ammonia aqua, 26 deg. carboys	lb.	.20 —	.....
Ammonium carbonate	lb.	.11 —	.12
Ammonium nitrate	lb.	(Fixed price)	.14
Ammonium, sulphate domestic	lb.	07¼ —	.07½
Amyl acetate	gal.	5.25 —	5.40
Arsenic, white	lb.	.16¼ —	.16½
Arsenic, red	lb.	.65 —	.70
Barium carbonate, 99 per cent	ton	80.00 —	90.00
Barium carbonate, 97-98 per cent	ton	65.00 —	67.00
Barium chloride	ton	70.00 —	90.00
Barium sulphate (Blanc Fixe, powder)	lb.	.03½ —	.04
Barium nitrate	lb.	.09½ —	.11
Barium peroxide, basis 70 per cent	lb.	.31 —	.34
Bleaching powder, 35 per cent chlorine	lb.	.02½ —	.02¾
Borax, crystals, sacks	lb.	.07½ —	.08¼
Brimstone, crude	ton	Nominal	
Bromine, technical	lb.	.65 —	.70
Calcium, acetate, crude	lb.	Nominal	
Calcium, carbide	lb.	12½ —	.13
Calcium chloride, 70-75 per cent, fused, lump	ton	22.00 —	23.00
Calcium peroxide	lb.	1.60 —	1.70
Calcium phosphate	lb.	.30 —	.31
Calcium sulphate	lb.	—	.....
Carbon bisulphide	lb.	.07 —	.07½
Carbon tetrachloride, drums	lb.	.14 —	.16
Carbonyl chloride (phoszene)		—	.....
Caustic potash, 88-92 per cent	lb.	.83½ —	.84
Caustic soda, 76 per cent	lb.	.06½ —	.06¾
Chlorine, liquid	lb.	.15 —	.18
Cobalt oxide	lb.	1.40 —	1.50
Copperas	lb.	01¼ —	.01½
Copper carbonate	lb.	.45 —	.....
Copper cyanide	lb.	.75 —	.78
Copper sulphate, 99 per cent, large crystals	lb.	.09 —	.09½
Cream of tartar, crystals	lb.	.61 —	.63
Epsom salt, bags	lb.	03½ —	.03¾
Formaldehyde, 40 per cent	lb.	19½ —	.20
Glauber's salt	100 lb.	1.00 —	1.10
Glycerine, bulk, C. P	lb.	67½ —	.70
Iodine, resublimed	lb.	4.25 —	4.35
Iron oxide	lb.	.13 —	.15
Lead, acetate, white crystals	lb.	.17 —	.17½
Lead arsenate (Paste)	lb.	.15 —	.18
Lead nitrate	lb.	Nominal	
Litharge, American	lb.	09½ —	.11½
Lithium carbonate	lb.	1.50 —	2.00
Manganese dioxide, U. S. P	lb.	.70 —	.75
Magnesium carbonate, technical	lb.	.10 —	.10½
Nickel salt, single	lb.	Nominal	
Nickel salt, double	lb.	Nominal	
Phoszene, see Carbonyl chloride		—	
Phosphorus, red	lb.	1.60 —	1.70
Phosphorus, yellow	lb.	1.25 —	.....
Potassium bichromate	lb.	.43 —	.45
Potassium bromide granular	lb.	1.45 —	1.50

Potassium carbonate calcined, 85-90 per cent	lb.	.60 —	65
Potassium chlorate, crystals	lb.	.40 —	42½
Potassium cyanide, 98-99 per cent	lb.	Nominal	
Potassium iodide	lb.	3 75 —	3 80
Potassium muriate 80-85 p. c. basis of 80 p. c	ton	350.00 —	...
Potassium nitrate	lb.	.30 —	.32
Potassium permanganate (U. S. P.)	lb.	4.00 —	4.10
Potassium prussiate, red	lb.	2.60 —	2.70
Potassium prussiate, yellow	lb.	1.27 —	1.30
Potassium sulphate, 90-95 p.c. basis 90 p.c	ton	Nominal	
Rochelle salts	lb.	.39 —	39½
Salammoniac, gray gran	lb.	.15 —	.16
Salammoniac, white gran	lb.	.15 —	.16
Sal soda	100 lb.	1.25 —	1.30
Salt cake	ton	22.00 —	23.00
Silver cyanide, based on market price of silver	oz.	—	
Silver nitrate	oz.	.53 —	.55
Soda ash, 58 per cent, light, flat	100 lb.	2.95 —	3.00
Soda ash, 58 per cent, dense, flat	100 lb.	3.50 —	4.00
Sodium acetate	lb.	.16½ —	.17
Sodium bicarbonate, domestic	lb.	.02¾ —	.03
Sodium bicarbonate, English	lb.	—	
Sodium bichromate	lb.	.19½ —	.20
Sodium bisulphite, powd	lb.	.06¼ —	.06½
Sodium chlorate	lb.	.20 —	.22
Sodium cyanide	lb.	.42 —	.44
Sodium fluoride, commercial	lb.	.18½ —	...
Sodium hyposulphite	lb.	.02½ —	...
Sodium molybdate, per lb. of Mo	lb.	2.50 —	...
Sodium nitrate, 95%	100 lb.	4.50 —	...
Sodium nitrite	lb.	.30 —	.35
Sodium peroxide	lb.	.49 —	.50
Sodium phosphate	lb.	.04 —	.04½
Sodium prussiate, yellow	lb.	.37 —	.38
Sodium silicate, liquid (60 deg.)	lb.	.03½ —	.04½
Sodium sulphide, 30 per cent., crystals	lb.	.02¾ —	.03
Sodium sulphide, 60 per cent., fused	lb.	.04⅞ —	.05
Sodium sulphite	lb.	.05 —	.06
Strontium nitrate	lb.	.25 —	.35
Sulphur chloride, drums	lb.	.06 —	.06½
Sulphur dioxide, liquid, in cylinders	lb.	.15 —	.40
Sulphur, flowers, sublimed	100 lb.	4.05 —	4.10
Sulphur, roll	100 lb.	3.70 —	3.85
Sulphur, crude	ton	Nominal	
Tin bichloride, 50 deg	lb.	Nominal	
Tin oxide	lb.	.75 —	.90
Zinc carbonate	lb.	.22 —	.25
Zinc chloride	lb.	.10¼ —	.11
Zinc cyanide	lb.	Nominal	
Zinc dust, 350 mesh	lb.	.17 —	.18
Zinc oxide, American process XX	lb.	.13½ —	14
Zinc sulphate	lb.	.06 —	.07

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.35 —	.40
Benzol, 90 per cent	gal.	—	
Toluol, pure water white	gal.	Nominal	
Xylol, pure, water white	gal.	.35 —	.50
Solvent naphtha, water white	gal.	.17 —	.22
Solvent naphtha, crude, heavy	gal.	.13 —	.16
Creosote oil, 25 per cent	gal.	.33 —	.35
Dip oil, 20 per cent	gal.	.29 —	.30
Pitch, various grades	ton	8.00 —	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05 —	1 10
Carbolic acid, crude, 50 per cent	lb.	.60 —	65
Carbolic acid, crude, 25 per cent	lb.	.35 —	.38
Cresol, U. S. P.	lb.	.18 —	20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.10 —	...
Alpha naphthol, distilled	lb.	1.60 —	...
Alpha naphthylamin	lb.	.58 —	.60
Aniline oil, drums extra	lb.	.26 —	.28
Aniline salts	lb.	.32 —	.34
Anthracene, 80 per cent	lb.	.50 —	.65
Benzaldehyde	lb.	4.00 —	4.50
Benzidine, base	lb.	1.75 —	1.85
Benzidine, sulphate	lb.	1.40 —	1.50
Benzoic acid U. S. P.	lb.	—	
Benzoate of Soda, U. S. P.	lb.	5.45 —	5.75
Benzyl chloride	lb.	1.75 —	1.85
Beta naphthol benzoate	lb.	7.00 —	8.00
Beta naphthol, sublimed	lb.	.85 —	.90
Beta naphthylamin, com	lb.	2.50 —	2.65
Diehlor benzol	lb.	.12 —	.18
Diethylaniline	lb.	4.00 —	5.00
Dinitro benzol	lb.	.34 —	.50
Dinitrochlorbenzol	lb.	.40 —	.42
Dinitronaphthaline	lb.	.55 —	.60
Dinitrotoluol	lb.	.55 —	.60
Dinitrophenol	lb.	.55 —	.57
Dimethylaniline	lb.	.57 —	.62
Diphenylamine	lb.	.85 —	1.00
H-acid	lb.	2.25 —	2.50
Metaphenylenediamine	lb.	1.85 —	2.00
Monochlorbenzol	lb.	.19 —	.22
Naphthalene, flake	lb.	.09½ —	.09¾
Naphthalene, balls	lb.	.10½ —	.10¾
Naphthionic acid, crude	lb.	1.40 —	1.50
Naphthylamin-di-sulphonic acid	lb.	1.00 —	1 10
Nitro naphthaline	lb.	.45 —	.50
Nitro toluol	lb.	.50 —	.55
Ortho-amidophenol	lb.	—	
Ortho-toluidine	lb.	1.00 —	1 20
Ortho-nitro-toluol	lb.	.75 —	1 00
Para-amidophenol, base	lb.	3.50 —	4 00
Para-amido-phenol, H. Cl	lb.	4 00 —	4 25
Paranitraniline	lb.	1.05 —	1 15
Para-nitro-toluol	lb.	1.50 —	1 60
Paraphenylenediamine	lb.	3.00 —	3 50
Para toluidine	lb.	2 25 —	2.50
Phthalic acid anhydride	lb.	4 50 —	6 50
Phenol, U. S. P.	lb.	.53½ —	.55
Resorcin, technical	lb.	6 00 —	7 00
Resorcin, pure	lb.	10.00 —	12 00
Salicylic acid	lb.	1.05 —	1 10
Salol	lb.	1.85 —	2 00
Sulphanilic acid	lb.	.32 —	.35
Tolidin	lb.	2 50 —	...
Toluidine-mixture	lb.	.75 —	.85

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	3.75 —	...
Corning, Ohio	bbl.	2.80 —	...
Somerset, Ky	bbl.	2.55 —	...
Wonster, Ohio	bbl.	2.38 —	...
Indiana	bbl.	1.98 —	...
Illinois	bbl.	2.12 —	...
Oklahoma and Kansas	bbl.	2.00 —	...
Caddo, La., light	bbl.	2.00 —	...
Corsicana, Tex., light	bbl.	2.00 —	1.32
California	bbl.	.98 —	...
Gulf Coast	bbl.	1.00 —	...

Fuel Oil

New York	gal.	.11 —	...
Pittsburgh	gal.	.07½ —	.10
Oklahoma-Kansa	bbl.	1.50 —	2.35
Texas	bbl.	1 50 —	1.75
Los Angeles	bbl.	1.52 —	...
San Francisco	bbl.	1.45 —	...

Gasoline (Wholesale)

New York	gal.	.24 —	...
Boston	gal.	.25 —	...
Pittsburgh	gal.	.26 —	...
Chicago	gal.	.21 —	...
Oklahoma	gal.	.25 —	...
San Francisco	gal.	.20½ —	...

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.19 —	.20
Cylinder, light	gal.	.34 —	.35
Cylinder, dark	gal.	.33 —	.34
Paraffine, high viscosity	gal.	.36 —	.37
Paraffine, 903 sp. gr	gal.	.29 —	.30
Paraffine, .865 sp. gr.	gal.	.21 —	.22

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f.o.b. Florida	gal.	.44 —	...
Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.50 —	...
Pine oil, destructively distilled	gal.	.43 —	.53
Pine-tar oil, sp. gr., 1.025-1.035	gal.	.30 —	...
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.35 —	...
Pine oil, light, sp. gr. 0.930, tank cars, f.o.b. works	gal.	.37 —	...
Pine oil, heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.26 —	...
Pine tar, thin, sp. gr. 1.060-1.080	gal.	.32 —	...
Turpentine, crude, sp. gr. 0.980-1.000	gal.	.40 —	...
Hardwood oil, f.o.b. Michican, sp. gr. 0.960-0.990	gal.	.21 —	...
Hardwood oil, f.o.b. Michican, sp. gr. 1.06-1.08	gal.	.19½ —	...
Wood creosote, ref. f.o.b. Florida	gal.	.31 —	...

Vegetable and Other Oils

Chioa wood oil	lb.	.20 —	.21
Cottonseed oil, crude	lb.	.17½ —	.18
Linseed oil, raw, cars	gal.	1.28 —	...
Peanut oil, crude	gal.	1.37 —	...
Rosin oil, first run	gal.	.35 —	...
Rosin oil, fourth run	gal.	.66 —	...
Soya bean oil, Manchuria	lb.	.18 —	.18½
Turpentine, spirits	gal.	.50 —	.51

Miscellaneous Materials

Barytes, floated, white, foreign	ton	40 00 —	50.00
Barytes, floated, white, domestic	ton	30 00 —	36.00
Beeswax, white, pure	lb.	.56 —	.64
Casein	lb.	.22 —	.30
Chalk, light, precipitated, English	lb.	—	...
Fel spar	ton	8 00 —	12.00
Fuller's earth, powdered	100 lb.	1 00 —	1.50
Ozokerite, crude, brown	lb.	.65 —	.75
Ozokerite, American, refined, white	lb.	.75 —	1 00
Red lead, dry, carlots	lb.	.10 —	.11¼
Rosin, 280 lb	bbl.	6 95 —	...
Soapstone	ton	10 00 —	12 50
Talc, American, white	ton	15 00 —	22 00
White lead, dry	lb.	.09 —	.10

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	Nominal	
Chrome cement, Grecian	net ton	Nominal	
Clay brick, 1st quality fireclay	per 1000	50.00 —	55.00
Clay brick, second quality	per 1000	35.00 —	40.00
Magnesite, raw	ton	30.00 —	35.00
Magnesite, calcined	net ton	85.00 —	90.00
Magnesite, Grecian, dead burned	net ton	135 00 —	140 00
Magnesia brick, Grecian, 9x4½x2½	per 1000	50 00 —	60 00
Silica brick			

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carlots, f.o.b. Niagara Falls, N. Y.	ton	160.00 —	...
Ferrochromium, per lb. of Cr	lb.	.50 —	...
Ferromanganese, domestic	ton	250.00 —	...
Ferromanganese, English	ton	325.00 —	...
Ferromolybdenum, per lb. of Mo	lb.	3 00 —	...
Ferrosilicon, 75 per cent, f.o.b. N. Y.	ton	—	
Ferrosilicon, 50 per cent, carlots, del., Pittsburgh	ton	165.00 —	175.00
Ferrosilicon, 50 per cent, contract	ton	100.00 —	175.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	2 35 —	2 45
Ferrouranium, f.o.b. works, per lb. of U	lb.	7 00 —	...
Ferrovanadium, f.o.b. works	lb.	3.50 —	4 50

Ores and Semi-finished Products

Antimony ore, per unit		1 60 —	1 75
Chrome ore, 48 per cent minimum, f.o.b. Cal., per unit	ton	1.50 —	...
Manganese ore, 48 per cent and over, per unit	ton	1 20 —	...
Manganese ore, chemical	ton	80 00 —	100 00
Molybdenite, per lb. of MoS_2	lb.	2 15 —	2 20
Tungsten, Scheelite, per unit of WO	ton	24 50 —	...
Tungsten, Wolframite, per unit of WO	ton	24 50 —	...
Uranium oxide, 96%	lb.	3 25 —	3 60
Vanadium pentoxide, 99%	lb.	10.50 —	...
Pyrites, foreign	unit	16 —	16½
Pyrites, domestic	unit	25 —	30

INDUSTRIAL

Financial, Construction and Manufacturers' News

New Companies

ALVORD & FRENSDORF, INC., Syracuse, N. Y. Capital, $200,000. To engage in the manufacture of fertilizer, glue, etc. Incorporators: S. and C. B. Frensdorf, and J. Buff, 112 Warner Street, Syracuse.

THE ATLAS PRODUCTS COMPANY, Chicago, Ill. Capital, $25,000. To engage in a general potash production business. Incorporators: B. Prentiss, P. Zak, and B. F. Cowan, Chicago.

BAMBERGER & ROBBINS, INC., Wilmington, Del. Capital, $50,000. To manufacture paints, varnishes, etc. Incorporators: James McClafferty, James P. Robbins and Samuel Waity, Wilmington.

THE BARNES CHEMICAL WORKS, Paterson, N. J. Capital, $250,000. To manufacture chemicals and allied products. Incorporators: John W., H. J., and L. E. Laffey, Paterson.

THE BERGOM PRODUCTS COMPANY, New York. Capital, $10,000. To manufacture chemicals, dyestuffs, and kindred products. Incorporators: J. M. Barry, A. C. Thiel and J. L. Fox, 571 West One Hundred and Fifty-ninth Street.

THE BIG SHOT LEAD & ZINC COMPANY, Ardmore, Okla. Capital, $50,000. To mine for lead and zinc. Incorporators: B. S. Curtis, A. T. West, and D. K. Pope, Ardmore.

THE BINDER PAPER BOX COMPANY, Newark, N. J. Capital, $25,000. To manufacture paper boxes, etc. Incorporators: E. Herman, Harry Levin, and K. Fitzgerald, Newark.

THE BLAST FURNACE PRODUCTS CORPORATION, Dover, Del. Capital, $1,000,000. To manufacture apparatus for blast furnaces, etc. Incorporators: Joseph Mann, Bloomfield, N. J.; Arthur P. McKinstry, New York; and Erwin B. Hallett, Brooklyn, N. Y.

THE CALDWELL GLASS COMPANY, Pittsburgh, Pa. Capital, $25,000. To manufacture glassware of various kinds. H. P. Fitzpatrick is the principal incorporator.

THE CENTURY MINING COMPANY, Miami, Okla. Capital, $300,000. To engage in a general lead and zinc business. Incorporators: L. B. Parker and George Weems, Miami, and G. H. Ennis, Mounds, Okla.

THE CONNORS STEEL COMPANY, Birmingham, Ala. Capital, $300,000. To construct and operate a rolling mill for the manufacture of steel hoops, bars, bands, channels, and other steel products. Incorporators: George W. Connors, W. M. Hoke, and S. S. Paul.

THE COMMERCIAL STEEL CASTINGS COMPANY, Marion, Ohio. Capital, $150,000. To manufacture open-hearth steel castings. Incorporators: J. D. Owen, C. A. Owen, D. W. Evans, George D. Copeland, M. C. McNeil, R. H. Beidenbaugh, and H. J. Barnhart.

THE COOSA CARBON COMPANY, Birmingham, Ala. Capital, $150,000. To engage in the development of graphite properties. Incorporators: H. W. Blake, W. A. Neal, P. McGeever, and Robert T. Epperson.

THE CHARLES E. DAVIS FOUNDRY COMPANY, INC., Rutland, Vt. Capital, $75,000. To operate a local foundry. Incorporators: Charles E. Davis, M. I. Mullin, and J. N. Page, Rutland.

JAMES H. DEDERICKS' SONS, INC., Jersey City, N. J. Capital, $30,000. To smelt, refine and deal in gold, silver and other metals. Incorporators: C. A. Cole, Arthur R. Oakley, Paul E. Birtsch, Jersey City.

EDINBURG PAINT & MANUFACTURING COMPANY, Edinburg, Va. Capital, $200,000. To manufacture paints, varnishes, etc.

THE FEDERAL PAPER CAN & CARTON COMPANY, New York. Capital, $10,000. To manufacture paper boxes and other paper specialties. Incorporators: C. C. Wippman, L. S. Lockhart, and E. C. Cushman, 51 Chambers Street.

THE FLORIDA GLASS COMPANY, Tampa, Fla. Capital, $250,000. To manufacture glass and glassware of various kinds. Incorporators: C. J. Earley, Paul T. Davis, and L. M. Stahl, Tampa.

THE GASOLINE ECONOMY COMPANY, Dover, Del. Capital $100,000. To manufacture devices for the use of oil and products thereof.

THE GOLDEN SPIKE MINING COMPANY, Oklahoma City, Okla. Capital, $125,000. To mine for lead and zinc. Incorporators: R. H. Drenna, F. E. Herrin, and O. D. Halsell.

THE HENDERSON PLANTATION COMPANY, Memphis, Tenn. Capital, $500,000. To operate cotton gins, cotton seed oil mills, etc. Incorporators: Frank Hayden, L. K. Salsbury, and J. S. Sbortle, Memphis.

THE HOFFMAN PERRY IRON & STEEL COMPANY, Youngstown, Ohio. Capital, $75,000. To operate a plant for the manufacture of iron and steel products. Incorporators: L. J., and Frank C. Hoffman, Youngstown.

THE HUGO BRAND LEATHER COMPANY, New York. Capital, $25,000. To manufacture leather and leather specialties. Incorporators: L. R. Benjamin, E. B., and H. Brand, 622 West One Hundred and Thirteenth Street, New York.

THE IRON CITY FOUNDRY COMPANY, Hamilton, Ohio. Capital, $50,000. To operate a large plant. Incorporators: Albert D. Stuckey and C. E. Freeman.

THE C. E. ISING CORPORATION, New York. Capital, $100,000. To manufacture chemicals and allied products. Incorporators: C. T. Johnson, Youngstown, O., and F. Baer, 550 West One Hundred and Seventy-eighth Street, New York.

THE JOPLIN-MIAMI LEAD & ZINC COMPANY, Oklahoma City, Okla. Capital, $100,000. To engage in a general mining business for the production of lead, zinc, etc. Incorporators: E. M. Butler, R. E. Burks, Oklahoma City, and E. Carman, Springfield, Mo.

THE KINGSPORT WOOD REDUCTION COMPANY, Chicago, Ill. Capital, $2,000,000. To reduce, distill, and treat wood. Incorporators: Harry H. Phillips Charles J. Horn, and Burrell J. Cramer, Chicago.

THE KETOL COMPANY, Newark, N. J. Capital, $50,000. To engage in the production of coal and wood tars. Incorporators: Charles S. Coe, East Orange; John H. Yocum, Newark, and Lewis M. DeForge, South Orange.

THE LA NORA MINING COMPANY, Chitwood, Mo. Capital, $48,000. To mine for lead and zinc. Incorporators: George G. Bayless, Carterville; Phil Gray, Webb City, Mo.

THE F. G. LASHER COMPANY, Brooklyn, N. Y. Capital, $75,000. To manufacture chemicals, dyestuffs, etc. Incorporators: F. W. Parker, D. Dosher, and F. G. Lasher, 104 Grove Street, Brooklyn.

THE EDGAR LEVINSTEIN COMPANY, Boston, Mass. Capital, $250,000. To manufacture chemicals and allied products. Incorporators: Harry R. Davies, Edgar Levinstein, and George L. Bishop, Boston.

THE LOCKPORT LEAD MINING COMPANY, Owenton, Ky. Capital, $30,000. To mine for lead, etc. Incorporators: J. T. Walker, H. C. Green, Sr., N. E. Foster, and F. H. Brown, Owenton.

THE LOOKOUT PAINT COMPANY, Chattanooga, Tenn. Capital, $100,000. To manufacture paints, varnishes, etc. J. H. Stewart is the principal incorporator.

THE LUCKY PAT MINING COMPANY, Miami, Okla. Capital, $150,000. To mine for lead, zinc, etc. Incorporators: L. C. Kropp, Vinita, Okla.; O. O. Snyder, and S. H. Mates, Pryor, Okla.

THE MENDLESON CORPORATION, Albany, N. Y. Capital, $2,000,000. To manufacture potash, chemicals, lime, etc. Incorporators: I. Mendleson, J. and L. Mendleson, 644-A Madison Avenue, Albany.

THE METALS & CHEMICAL CORPORATION, Dover, Del. Capital, $100,000. To manufacture chemicals, colors, dyes, etc.

THE MIAMI ZINC & LEAD COMPANY, Portland, Me. Capital, $3,000,000. To mine for zinc and lead. Incorporators: E. V. Mann, E. H. Irwin, and C. D. Booth.

THE MO-VA-CU PRODUCTS CORPORATION, New York. To manufacture chemicals, oils, etc. Incorporators: C. A. Rucker, Jr., J. J. Haesler, and W. A. White, 229 West One Hundred and Ninth Street, New York.

THE NATIONAL STEEL BARREL COMPANY, Cleveland, Ohio. Capital, $200,000. To manufacture steel products. Incorporators: P. R. Long, C. F. Schriner, John A. Nally, and J. J. Schriner.

THE NORTH CAROLINA TIN COMPANY, Cherryville, N. C. Capital, $100,000. To manufacture tin. Incorporators: M. S. Mauney, D. A. Rudisill, and N. A. Stroup.

THE NATURAL CHEMICAL PRODUCT COMPANY, Lexington, N. C. Capital, $350,000. To manufacture chemicals and allied products, mainly potash from feldspar. Incorporators: C. Berg, of New York, president-chemist; G. W. Mountcastle, vice-president; W. L. Crawford, secretary-treasurer, both of Lexington.

THE PITTSBURGH THERMOLINE COMPANY, Pittsburgh, Pa. Capital, $100,000. To manufacture compressed liquid gas for the welding of iron and other metals. Incorporators: John P., Harry O., and Walter E. Eichleay, Pittsburgh.

THE RAINBOW MINING & DEVELOPMENT COMPANY, Miami, Okla. Capital, $25,000. To engage in a general mining business. Incorporators: F. E. Atchlet, W. A. Spurlin, and R. M. Radcliffe, all of Erick, Okla.

THE RED-OINT-A CHEMICAL COMPANY, Portland, Me. Capital, $10,000. To manufacture chemicals, etc. Incorporators: A. M. Brown, Winchester, Mass.; W. D. Hobson, Portland.

THE SHARTEL MINING COMPANY, Oklahoma City, Okla. Capital, $25,000. To mine for lead and zinc. Incorporators: Charles Hoopes, J. W. Shartel, and W. C. Jones, Oklahoma City.

THE SHUTTLEWORTH-WOLLNY COMPANY, New York. Capital, $10,000. To manufacture paper, paper boxes, etc. Incorporators: C. J. Wollny, F. Keiller, and W. E. Shuttleworth, 474 West Broadway, New York.

DAVID H. SMITH & SONS, INC., Brooklyn, N. Y. Capital, $100,000. To manufacture iron and steel products. Incorporators: D. H. Smith, Mahwah, N. J.; M. F. Smith, Brooklyn, N. Y.; and J. C. Snyder, 256 Broadway, New York.

THE STAMBAUGH IRON COMPANY, Cleveland, Ohio. Capital, $10,000. To operate a local iron works. Incorporators: F. McKenzie and F. J. Moriarity.

Construction and Operation

Alabama

BESSEMER.—The National Steel Products Company has recently acquired a large piece of property and is planning for the immediate construction of a new plant. It is expected to have the works completed and ready for operation within three months.

Arizona

VERDE.—The United Verde Extension Mining Company is having plans prepared for all buildings required for the new townsite at its local smelter. Sewer, water, and electric lighting system will also be installed, the entire work being estimated to cost approximately $2,000,000.

RAY.—The Ray-Hercules Copper Company is rushing to completion the erection of its new initial mill unit, and is planning to inaugurate operations at an early date. When completed, the first unit of the plant will have a capacity of 1,500 tons of ore daily.

Arkansas

NORTH LITTLE ROCK.—Fire recently destroyed a large portion of the Buckeye Cotton Oil Mill of the Procter & Gamble Soap Company, Cincinnati, Ohio, with loss said to be approximately $400,000. It is reported that the works will be immediately rebuilt. A. B. Carr is manager.

LITTLE ROCK.—The Arkansas Foundry Company has acquired property at the foot of East Sixth Street, and is planning for the establishment of a new foundry for the production of gray iron castings for railroad construction, to have a capacity of about 15 tons daily.

YELLVILLE.—The Deep Mining Company, recently organized, is plannnig for the early development of deep ore bodies on Cowan Barrens, between Yellville and the Rush mining camp on Buffalo River.

California

MARTINEZ.—The Atlas Powder Company is said to be planning for the construction of a large addition to its Giant Powder plant. The company has recently acquired a site consisting of about 200 acres of land adjoining the works.

SAN DIEGO.—The United States Government, Navy Department, has awarded a contract to John W. Danforth Company, 70 Ellicott Square, Buffalo, N. Y., for the

construction of a new local concrete and steel fuel oil plant, to cost about $275,000.

OAKLAND.—The Judson Manufacturing Company is making rapid progress in the construction of a new addition to its rolling mill at the foot of Park Avenue.

OAKLAND.—The Spencer-Kellog Company, Edgewater, N. J., is planning for the construction of a new linseed oil plant on a local site now under consideration. The works, which will be among the largest in the world, are estimated to cost $400,000.

SAN FRANCISCO.—The Pacific Gas & Electric Company is planning for extensive improvements and additions to its plant at Fresno. A portion of the work, which will cost about $400,000, has been commenced.

SAN FRANCISCO.—Announcement has been made that effective January 1, 1918, the Pacific Hardware & Steel Company and Baker & Hamilton will be merged into one corporation, to be known as the Baker, Hamilton & Pacific Company, capitalized at $4,250,000. Alexander Hamilton is president of the new company.

FILLMORE.—The Ventura Refining Company has completed the construction of its new local wax refinery, and operations have been inaugurated. The product of the new plant is in great demand for the making of explosives, paper boxes, etc.

KESWICK—The Mountain Copper Company is having plans prepared for the construction of a new addition to its oil flotation plant for the treatment of copper ore at the Minnesota station, between Keswick and Iron Mountain, to double the present capacity. When completed, the works will have an output of about 1,040 tons daily.

Colorado

CRIPPLE CREEK—The Vindicator Consolidated Gold Mining Company has completed improvements in its 600-ton flotation mill. At the present time the mill produces about 12 tons of concentrate daily, running from $25 to $30 per ton.

Connecticut

ANSONIA.—The American Brass Company has taken out a building permit for alterations and improvements in a two-story building, about 30 x 100 ft., now used for storage purposes, to provide for increased capacity.

NEWINGTON.—Construction is being rushed to completion on the new two-story paper mill being erected for Thomas F. Garvan. The structure is about 47 x 147 feet, and the installation of the necessary equipment has been commenced.

STAMFORD.—The American Synthetic Colors Company is planning for the construction of a large addition to its plant to provide for increased capacity. The structure is estimated to cost $30,000.

WATERBURY.—The Connecticut Brass & Manufacturing Company, which recently took over the Tilling Brass Company, is planning for the erection of a one-story addition to its plant to provide for increased capacity.

Delaware

NEWARK.—The plant of the Jacob Thomas Company, manufacturer of wall paper, was completely destroyed by fire on Jan. 11, with loss estimated at about $225,000. The destruction of the plant has thrown about 150 hands out of employment

Georgia

CAMILLA.—The W. F. Cullens Fertilizer Company is planning for the erection of a large new addition to its plant, to provide for increased capacity.

Illinois

CHICAGO.—The Standard Steel Car Company has had plans prepared for the construction of a new one-story machine shop at its Hammond, Ind., works. The structure, which will be about 250 x 800 feet, is estimated to cost $200,000.

CHICAGO.—Rapid progress is being made by the William Glader Machine Works, North Ann Street, in the construction of a new three-story plant. The structure will be about 50 x 100 feet and cost $20,000.

Indiana

LOGANSPORT.—Fire, on January 8, destroyed a portion of the plant of the Logansport Casting Company, a section of the Western Motor Works, with entire loss estimated at $70,000. A. W. Pattu is manager.

MUNCIE.—The Eagle Foundry Company has filed plans for the construction of a new one-story addition, about 25 x 125 ft., on Willard Street. Contract has been awarded.

MUNCIE.—Fire on January 10 destroyed a portion of the plant of the Central Indiana Gas Company, Brotherton Street and Big Four Railroad, with loss estimated at $15,000. It is said the company will immediately rebuild.

Iowa

BURLINGTON.—The North Western Stamping Company has had plans prepared for the construction of a new one-story factory, about 100 x 300 feet, at its plant. A. J. Klein, Burlington, is the architect

Louisiana

BOGALUSA.—Operations have been inaugurated in the new plant of the Bogalusa Paper Company, just completed, at a cost of $1,500,000. The plant will be operated largely on waste from the works of the Great Southern Lumber Company, situated near here.

SHREWSBURY.—The Planters' Fertilizer & Chemical Company, controlled by Armour & Company, Chicago, Ill., has just completed the erection of a large plant for the manufacture of boneblack. This is the first plant of its kind in the South, and the output, which is most universally used in the refining of sugar, will be utilized almost exclusively in this State.

BREAUX BRIDGE.—The Southern States Oil & Gas Company, Indianapolis, Ind., has acquired property on Banard Street, about 500 x 1000 ft., and is planning for the erection of a large new oil refinery. This location gives the company both water and rail facilities for transportation.

NEW ORLEANS.—The United Chemical & Organic Products Company, which recently acquired the local plant of the Hirsch-Stein Company of Chicago, has completed all building units in accordance with its original plans. The company will specialize in the production of commercial chemicals and by-me products. An investment of approximately $500,000 is represented in the new construction, etc.

Maryland

BALTIMORE.—The Piedmont-Mt. Airy Guano Company has filed plans for the construction of a new fertilizer building to cost about $60,000. Contract for erection has been awarded.

BALTIMORE.—Fire recently destroyed a portion of the plant of the American Propeller Works, Light Street, with loss estimated at approximately $90,000. The company is considering plans for the immediate reconstruction of the destroyed section.

CURTIS BAY.—The Industrial Alcohol Company has awarded a contract to the Austin Company, Bulletin Building, Philadelphia, Pa., for the construction of three new two-story manufacturing buildings to cost about $100,000.

SPARROWS POINT.—The Bethlehem Steel Company will build new one-story addition to its plant, about 30 x 35 ft., and 35 x 60 ft.

Massachusetts

EVERETT.—The New England Oil, Paint & Varnish Company is making rapid progress in the construction of its new one-story factory addition, about 30 x 48 ft. The company is planning to complete the structure and commence the installation of machinery at an early date

EAST CAMBRIDGE.—Fire recently destroyed the local car-building and repair shops of the Boston & Maine Railroad, including damages to the power house, roundhouse, machine shop and blacksmithing works. The entire loss is estimated to be approximately $150,000. It is said that the rebuilding will be commenced at once

LOWELL.—The International Steel Company, Middlesex Street, has taken out a building permit for the construction of a new addition, about 20 x 100 feet, to its plant

MARLBORO.—The Lapointe Machine Tool Company, Tower Street, is making rapid progress in the construction of a large new addition to its plant, to provide for increased capacity.

SPRINGFIELD.—The Springfield Aircraft Corporation has commenced the construction of a new addition to its plant to cost $50,000. Wyckoff & Lloyd, Springfield are the contractors.

SPRINGFIELD.—The Fleming Foundry Company has filed plans for the construction of a new two-story addition, about 50 x 55 feet, to its foundry. Contract has been awarded to the W. A. Newton Company, Springfield.

WORCESTER.—The Worcester Glass Company has commenced operation in its new plant on May Street, to be devoted to the manufacture of French mirrors, bevel plates, automobile shields, etc.

Michigan

JACKSON.—Fire completely destroyed the plant of the Perlman Rim Company, manufacturer of automobile rims, etc., recently, with loss estimated at approximately $80,000.

Minnesota

MINNEAPOLIS.—Fire recently completely destroyed the large plant of the Kansel Foundry Company, Dartmouth Street and Twenty-seventh Avenue, S. E. It is said the works will be rebuilt at once. John Kansel heads the company.

Missouri

KANSAS CITY.—The Sinclair Refining Company, Tulsa, Okla., has completed all plans for the construction of its new oil distributing station at Harrison Street and the Kansas City Railway Terminal. The new plant will comprise a large oil filling station, pump house, boiler room and locker room, one-story repair plant and garage, three-story and basement, barrel house, and administration building. The Leonard Engineering Company, McCormick Building, Chicago, Ill., is engineer and contractor.

ST. LOUIS.—The St. Louis Malleable Casting Company, Conduit Avenue, has completed all plans for the construction of a new plant to comprise a forge shop, machine shop, foundry, electric power plant, and auxiliary structures. The entire works, when completed, are estimated to cost about $100,000.

Montana

BAKER.—The Treasure State Gas & Oil Company, which was recently taken over by New York interests, is planning for the immediate installation of a large carbon plant on Cabin Creek, about twenty miles north of Baker. The company will also sink three more wells within the next few months for the purpose of procuring sufficient gas to supply the requirements of the carbon plant.

Nebraska

OMAHA.—The laboratory and administration building of the American Smelting & Refining Company was recently destroyed by fire, with loss estimated at approximately $25,000.

New Jersey

DOVER.—One of the comparatively new and permanent industries to be established and located in the Dover manufacturing district is the International High Speed Steel Company. Their plant is located along the Delaware, Lackawanna & Western Railroad, about two miles from the center of Dover. They manufacture hollow and solid rock drill steel, which is used chiefly for mining purposes. Before the declaration of war in Europe, hollow rock drill steel was not made in the United States, and at the present time the International High Speed Steel Company is the only concern in the United States that manufactures hollow steel. They now have orders sufficient to keep their plant in operation at capacity for the next two years. None of these orders are war orders. All current for power, lighting and electric furnaces is supplied by the New Jersey Power & Light Co.

EDGEWATER.—Spencer Kellog & Sons have filed plans for the construction of a new five-story addition to their oil manufacturing plant, about 30 x 50 feet. Contract for construction has been awarded to the John W. Ferguson Company, 152 Market Street, Paterson.

BLOOMFIELD.—Organization papers have been filed by the Mayland Manufacturing Company, notifying of intent to operate a chemical manufacturing works at 71 Willett Street. Anthony J. Mayland heads the company

BOUND BROOK.—For the purpose of increasing its capacity, and for the completion of a large Government order, the Cyclo Chemical Company, Bound Brook Road, manufacturer of chemicals, has commenced the construction of a large new addition to its plant. Frank N. Goble, 1 East Forty-second Street, New York, has the contract for erection.

HOBOKEN.—Fire recently destroyed the plant of the Gatti-McQuade Company, manufacturer of mill supplies and paper, with loss estimated at approximately $250,000.

JERSEY CITY.—The Humphrey Mantle Company, formerly located at Gloucester, has acquired a four-story factory building at 61-67 Bishop Street, and is planning to install equipment at once for the manufacture of gas mantles.

HARRISON.—The National Oil Products Company, Essex Street, is planning to greatly increase the capacity of its local plant, and has commenced the construction of several new additions for this purpose.

NEWARK.—The Butterworth-Judson Corporation, Avenue R, manufacturer of chemicals, has taken out a building permit for the construction of a new two-story addition to its plant, about 60 x 105 ft. The structure will cost $12,000.

NEWARK.—A new one-story brick condenser house addition, about 40 x 60 ft., will be erected at the chemical manufacturing plant of the Maas & Waldstein Company, Avenue R. The company has taken out a building permit for the structure.

KINGSLAND.—The Nitro Chemical Corporation, 20 Broad Street, New York, has recently acquired a portion of the local plant of the Canadian Car & Foundry Company, and is planning to commence immediate construction of about twenty-five new buildings, 60 x 400 ft., to be devoted to the manufacture of picric acid for the Government. When running to capacity, it is expected that the plant will have an output of approximately 800,000 pounds monthly of wet picric acid, which is used in the manufacture of hand grenades. About 4000 hands will be employed. Contract for the construction of the new plant has been awarded to W. J. Burke, Lyndhurst.

PERTH AMBOY.—Fire, on Jan. 12, destroyed a portion of the plant of the Roessler & Hasslacher Chemical Company, with loss estimated at about $25,000. The company has recently conveyed to the General Bakelite Company, manufacturer of insulation specialties, a subsidiary organization, property at Fayette and Rector Streets. It is said that the site will be used for extensions to the latter company's plant.

TRENTON.—The Globe Rubber Tire Company is planning for the construction of additions and improvements at its plant to provide for increased capacity.

New York

NEW YORK.—The Andes Exploration & Smelting Corporation, 68 William Street, has filed notice of a change in its corporate name to the Andes Electric Corporation.

BROOKLYN.—Lehn & Fink, 39 Sedgwick Street, manufacturers of chemical compounds, etc., have had plans prepared for the construction of a new addition to its brick plant to cost about $60,000. Buchman & Kahn, 30 East Forty-second Street, are the architects.

BROOKLYN.—The Continental Varnish Company, Newark, N. J., has awarded a contract for the erection of its proposed new factory group to be located at Ingraham Street and Varick Avenue. The new works will include a one-story main building, 60 x 80 ft., varnish house and garage, mixer building, and auxiliary structures, the entire work to cost $25,000. The Amsel Construction Company, 927 Broadway, Brooklyn, is the contractor.

FARMINGDALE, L. I.—The Farmingdale Chemical Company, manufacturer of chemicals and allied products, has acquired the plant of the E. C. Nelson Manufacturing Company, Farmingdale, for a consideration of about $75,000, and is planning to operate the works for the manufacture of chemicals which were obtained from Germany before the war.

LONG ISLAND CITY.—The Akron Tire Company, Honeywell Street and Skillman Avenue, has had plans prepared for the construction of a new one-story brick addition, about 50 x 95 ft., to its plant. The structure will cost $12,000.

LONG ISLAND CITY.—The Van Iderstine Company, Railroad Avenue, manufacturer of soaps, etc., is planning for the immediate construction of a new six-story reinforced-concrete plant, about 90 x 120 ft., on Newtown Creek, to cost about $70,000.. Plans have been prepared.

LONG ISLAND CITY.—The Pittsburgh Plate Glass Company is planning for the erection of a large new plant, about 260 x 280 ft., to be located on Hunters Point Avenue. The works are estimated to cost $350,000. and plans are now in course of preparation.

LITTLE FALLS.—Fire recently damaged the plant of the Barnet Leather Company, East Mills Street, manufacturer of leather. The destroyed section will be immediately rebuilt.

JAMESTOWN.—The Curtis Machine Company, East Second Street, which was engaged in the manufacture of propellers for aeroplanes for the Government, was partially destroyed by fire recently, with loss estimated at $35,000.

BALLSTON SPA.—Fire recently destroyed a portion of the plant of the American Hide & Leather Company, which is engaged on United States Army contracts, with loss estimated at $35,000. The tannery will be immediately rebuilt.

North Carolina

ASHEVILLE.—Anson G. Betts & Company, operating a mine at Shut-in-Creek for the production of iron ore, has greatly increased its output since the entrance of the United States in the war, and is planning for further development work.

CHARLOTTE.—Fire recently destroyed the local plant of the Buckeye Cotton Oil Company, with loss estimated at $100,000. The main plant of the company, which is located on the outskirts of the city, was not damaged.

Ohio

CANTON.—The ten new steel mills constructed as an addition to the plant of the Berger Manufacturing Company at a cost of approximately $4,000,000 will be completed at an early date, and the company is planning to inaugurate operations. The new additions will increase the output of the plant from 100,000 tons a year to about 160,000 tons.

CASTALIA.—The Castalia Cement Company is seriously considering the construction of a large local plant to be devoted to the production of potash as a byproduct.

COLUMBUS.—Fire, on January 9, destroyed the local plant of the American Chain Company. The loss is estimated at $150,000. The plant was engaged in the manufacture of chains for the Government, and about 800 employes are thrown out of work.

MARION.—The Commercial Steel Castings Company, recently incorporated with a capital of $150,000 is planning for the immediate construction of a large plant to have a capacity of about 20 tons of finished castings daily. The new works will give employment to about 125 hands for initial operations.

YOUNGSTOWN.—The Liberty Steel Company, which is now constructing an eight-mill tinplate plant near Warren, is planning for the construction of four additional mills, making it a twelve-mill plant. The works were originally planned for the production of steel sheets, but the procedure was changed when the heavy demand for tin became apparent.

YOUNGSTOWN.—The Carnegie Steel Company has inaugurated operations at its new bar mill just completed. Three other mills are also in course of construction.

Oklahoma

OIL CITY.—The American Industrial Oil Company, Oklahoma City, has acquired the Kenthoma property consisting of about 90 acres, and is planning for the immediate construction of a new refinery. The company has awarded a contract to B. Stutsel, Oil City, for the drilling of thirty-five additional wells.

Pennsylvania

BRADFORD.—S. A. Mundy and associates have organized a new company with a capital of $3,500,000, and are planning for the erection of a large pulp mill to cost about $1,000,000 in southern Ontario. It is said the mill will provide employment for approximately 200 returned Canadian soldiers.

JOHNSTOWN.—Fire recently destroyed the benzol manufacturing plant of the Cambria Steel Company, with loss estimated at $30,000. The company will commence the rebuilding of the works at once.

NEWPORT.—The American Manganese Company is planning for improvements in its plant. Contract has been awarded for the relining of its local stack.

PHILADELPHIA.—The Thomas Potter Sons & Company, Second and Erie Avenues, manufacturers of linoleum, have had plans prepared for alterations in their plant.

PITTSBURGH.—The hammer shop and 21-inch mill at the Park plant of the Crucible Steel Company, Thirty-first and Smallman Streets, was destroyed by fire recently with loss estimated at about $30,000. The company will immediately rebuild.

SCRANTON.—The American Color Company, Coal Exchange Building, has taken bids for the construction of a new addition to its plant at Penn Avenue and Carbon Street, to cost $40,000.

TIONESTA.—Fire, due to an explosion, recently destroyed the plant of the Interior Oil & Gas Company, with loss estimated at $15,000.

South Carolina

FLORENCE.—The main seed house of the Southern Cotton Oil Company's plant, including machinery, equipment and 700 tons of cotton seed, was destroyed by fire recently, with loss estimated at $70,000.

Tennessee

HADLEY'S BEND.—The United States Government, War Department, is planning for the construction of a large new manufacturing plant to be devoted to the production of explosives at Hadley's Bend, near Nashville. When running to capacity, the plant is estimated to give employment to about 15,000 hands. The project will require an investment of approximately $60,000,000. Contract for construction has been awarded to the Thompson-Starrett Company, New York.

BON AIR.—The Bon Air Coal & Iron Corporation is progressing very rapidly with its development plans, and has just opened two new mines at Eastland and Bon Air. The company is planning to increase the output to about 2,000 tons daily. The coke ovens at Eastland are now being prepared for the manufacture of furnace coke to be supplied to the Allens Creek iron furnace. This company was recently organized with a capital of $10,000,000.

Texas

DALLAS.—The Texas Steel Company, which recently acquired the Rusk foundry property at Rusk, is planning to inaugurate operations at the plant within the next three months for the manufacture of pig iron and iron pipe. The company is also considering the erection of a large steel plant of 700 tons daily capacity at Beaumont.

ORLA.—The Standard Sulphur Company, Detroit, Mich., has acquired property near Orla on the Santa Fe Railway, and is planning for the construction of the initial unit of its plant, to have a capacity of 100 tons of refined sulphur daily. Estimated cost of the project is $75,000.

Utah

GUNNISON.—The Gunnison Valley Sugar Company is making rapid progress in the construction of its large new plant, and it is expected that the works will be completed early in the spring. The cost of the new factory is said to be $500,000.

SALT LAKE CITY.—The Utah-Idaho Sugar Company, Vermont Building, has acquired property, about 93 acres, near Sunnyside, as a site for the construction of a large new sugar factory.

Virginia

HUNTINGTON.—The Virginian Potteries Company, recently organized, is planning for the construction of a new plant for the manufacture of pottery. The first unit of the works will be about 150 x 500 ft. W. H. Dunn is manager.

West Virginia

CLARKESBURG.—Fire recently destroyed a portion of the plant of the Norwood Glass Company, with loss estimated at $75,000, throwing about 300 hands out of employment. It is said that the plant will be immediately rebuilt. E. Hockstrosser is general manager.

CHARLESTON.—The United States Government has purchased about 1500 acres of land near Charleston, and is planning for the construction of a large plant for the manufacture of explosives, powder, etc., at a cost of $9,000,000.

Washington

LA GRANDE.—The American Nitrogen Products Company is planning for the installation of three new electric ovens, to provide for increased capacity. Contract has been awarded to the National Engineering & Equipment Company, L. C. Smith Building, Seattle.

Wisconsin

MENASHA.—The plant of the Wisconsin Rendering Company was recently destroyed by fire, with loss estimated at $10,000. The destroyed section will be rebuilt, it is said.

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A Legislative Solution of the Niagara Problem

FROM a bill introduced in the Senate of the State of New York by Mr. Gibbs on Jan. 15, 1918, we extract the following:

> "The sum of three million dollars ($3,000,000), or so much thereof as may be necessary, is hereby appropriated, payable out of the moneys realized under the sale of bonds as provided by section one of this act, to be expended by the commissioners of the state reservation at Niagara for the preparation of plans, specifications and estimates and the construction and equipment of a hydro-electric power plant, to be constructed under their supervision and control on land belonging to the state on the state reservation at Niagara, which plant when completed and equipped shall develop not less than five hundred thousand horsepower."

This indicates a capital cost of not more than $6 per horsepower developed! An engineer might doubt his ability to do so much within the limits of the appropriation; but provision is made, with great foresight, for the limitations of mere engineering ability:

> "The legislature shall prescribe the method and manner by which such commissioners shall obtain the necessary plans and specifications and estimates and prescribe their powers and duties in connection with the construction and operation of such plant."

An excellent example of the Bolshevik principle that any feat can be achieved by legislative action.

Meanwhile some Senator might with advantage introduce the following amendment:

> "The sum of thirty cents (30c.), or so much thereof as may be necessary, is hereby appropriated, to be expended for the elementary education of Mr. Gibbs in the subject of the cost of hydro-electric development."

The War Department Discovers the Chemist

FROM the time the United States entered the war to the present day there have been a few people who realized the importance of the chemist in the general scheme of industrial affairs. And when it was proposed to take him from his tasks and make a soldier of him, there were a few voices raised in opposition.

Comes now the Adjutant General of the Army, however, with official recognition of the importance of the chemist in industry. Through an order of the Adjutant General provision has been made whereby manufacturers of essential war materials who have lost chemists through the first draft may again obtain the services of these men, and those now threatened with the loss of chemists through the present draft may retain them. The request for exemption must come from the manufacturers; applications from the men will not be considered. Manufacturers thus affected should apply to the Chemical Service Section, N. A., New Interior Building, Washington, D. C., for the regulations governing the transfer of men already drafted or the possible reclassification of men not yet called.

The Need of Co-ordination at Washington

CONSIDER the United States as being in business, for war is business on so vast a scale as to transcend any other enterprise with which it might be compared. The particular feature of this business is production; munitions and supplies must be made and taken to armies in the field. It has been said that this is a war of production and transportation. Another feature of this business is that it is incidental to our political life and is not the normal pursuit of our political officers. Being incidental, it is conceivable that it may not be run efficiently by men selected for reasons wholly foreign to the making of war, and consequently unfamiliar with its *modus operandi*. A logical antidote for this inevitable inefficiency is to model the nation's business of the moment along the lines of private industry.

Now private industry has been the subject of searching analysis in recent years, with the result that problems of production have been pretty well solved and standardized. The production engineer has been having his innings in business, and he has made some effective hits. One of the conditions which he regards as fundamental in a manufacturing business is complete co-ordination of the work of the several departments that contribute to the finished product. The principle is axiomatic. It were unwise for an automobile maker, for instance, to allow the production of wheels, brakes, engines and bodies to proceed promiscuously, lest his unsystematic methods bring him to grief. Or, in more homely vein, he were a poor chef who would so direct the preparation of a dinner that the dessert spoiled before the soup was prepared.

In simple affairs, co-ordination may be accomplished by an orderly mind; but for complex industrial problems, production charts are resorted to by engineers in order to visualize production and enable the responsible head to co-ordinate the different branches of the work.

With this background we may now consider a fundamental trouble at Washington and prescribe the remedy. There has been a lack of co-ordination in the production program. Each officer or official responsible for a particular item has made a blind drive for production without regard to the relation of his part to the whole. Production charts are an unknown quantity in some of the offices, and there is no centralized authority responsible for the entire production program. There is no one to order a lag here or acceleration there in order to prevent congestion at some points and famine at others. Finally, production has not been co-ordinated with transportation, and the resulting jam is a matter of recent history. The fuel order, in the last analysis, was a public confession of lack of co-ordination at Washington.

The remedy lies in immediately charting the work of all the procurement divisions and co-ordinating the entire production and transportation program by the appointment of a responsible head. The charting is more important and should be done first, because charts will confound and expose an incompetent director, whereas they would be the first requisite of an able man. Failing the immediate accomplishment of these things, we will have fresh disasters to face in the course of a few months or even weeks.

Misdirecting Directors

IN HIS address before the St. Louis meeting of the American Institute of Chemical Engineers, which we print elsewhere, Mr. Frank Hemingway made some observations in regard to companies engaged in chemical industry which we think important. "I know of many companies of large size," he said, "whose boards of directors are composed wholly of financiers and business men possessing no chemical knowledge whatsoever, and in which there is no co-ordination between the directing head, the chemists and engineers or chemical engineers, the sales department and the purchasing department." This is not a surprising declaration; it is even a familiar situation in American industry, chemical or otherwise, and it is a fault of which banks and financial institutions have not yet taken adequate notice. It is a legacy of High Finance developed in the palmy days of trust flotation, and we are still suffering from it. The Board of Directors was made a kind of a show-window of corporations for stock-selling purposes. It was held that with a handsome array of money-makers on the directorate any new company would be sure to earn fat dividends. We know better, but we do not believe better, because this notion has become a tradition.

The board of directors of a manufacturing concern is charged with grave responsibilities. It bears the obligations of the welfare of the corporation, of the joint and not the separate fortunes of the stockholders, and it has to do with the relations of the corporation to industry, to its employees, to the community and to society. It is not merely a finance committee. Generally speaking, the better and more competent the whole board, the less work is there for the finance committee to do. This concept of the situation is so frequently lost sight of as to constitute a grave menace to national industry. The finance committee has to do with the disposition of earnings and with borrowing money to be spent by the corporation; but what is the use in borrowing money if you do not know how to use it? Such a board as Mr. Hemingway described does not know how to use it.

The manufacturing, selling, purchasing and research departments of an industrial concern constitute its heart. If a director of an organization is not familiar with these features and with their relations to each other, his presence as a member of the board is an act of culpable neglect. No matter how rich or successful he may be, he is useless as a director until he knows what is going on within the establishment.

Our ideas of the functions of a board of directors are so loose that offenses against industry by inadequate or defective personnel are of frequent occurrence and no heed is paid to the fact. Occasionally a swashbuckling speculator bulldozes his way into membership by means of another traditional fiction that any considerable ownership of stock entitles the holder to personal representation in the body no matter how ignorant or incompetent he may be to guide the delicate and complex mechanism of affairs that the corporation has in hand. The stigmata of such a man are likely to show in the annual report. "Unnecessary charges have been eliminated," we learn, and on investigation discover that the new director has begun to cut out deadwood, which is his favorite occupation. This consists in discharging

men who have served the company for many years and who may have needed bracing but, likely as not, were faithful and needful to the organization. Affluent traders of this type are likely to hate research as smacking of theorism, which is anathema to their souls, and by the time such a man has been mixed up in the affairs of a manufacturing concern for a year, he has cut and slashed and broken the spirits of the men who remain until the whole organization is crippled—sometimes beyond repair. Generally speaking, it is a hazardous thing to tie up to an unsuccessful man, but the successful man, ignorant of the details of an industry and whose mind is closed by vanity, is a greater danger.

American industry is in a good deal of a jumble. It needs guidance. Its difficulties are rather with theory than with finance. We do not claim that a board of directors of a manufacturing corporation should consist of department heads of the company. That would involve letting the concern run itself, while it is right and proper that the directors should be representative of the stockholders and not alone of the president. But these men are useless unless they understand the business well enough to know its actual needs. Directors should be retained by stockholders for the work they can do and for their good counsel. Their business is to conserve the welfare of the whole corporation and this requires knowledge and understanding of the business in hand as well as acumen in other affairs. They should not be selected to conserve special interests or because they have made fortunes in some entirely unrelated walk of life. It is time to take annual stockholders' meetings more seriously and to shake up the proxy committees. A sense of this need may be obtained by the comparison of the live, efficient and capable boards of a number of the great American industrial corporations with the complacent body of merchants and bankers that sit in idleness and vanity on the boards of a vast number of concerns even now engaged in the struggles of birth.

Better Work Needed

THE loss of the Tuscania with American troops aboard, of whom happily but few were lost, brings to us a fuller realization of how fortunate it is that the submarine menace has been largely reduced in the past few months. But the curtailing of destruction by submarines cannot lessen our chagrin that our shipbuilding has proceeded so slowly. While it is only ten months since our formal declaration of war, it is a full year and more since the necessity of our building ships as rapidly as possible was made clearly apparent. In retrospect we seem to have done very little indeed. Possibly it is harsh to judge us by our own expectations, but if that is to be the standard we certainly are condemned. We were to start a perfect procession of wooden boats, almost a pontoon, tandem fashion, by Oct. 1, 1917. It took us months to realize the chimerical nature of that project.

We have a hard and immeasurably important task before us, and it should do us good to think for a moment of the mistakes, the egregious blunders we have made, particularly since the chances for blundering are not all past. Like the poor, we have them with us always. The wooden ship idea was embraced because, forsooth, we had no plates! What is the condition to-day? The plate mills are unable to operate at capacity because of the breakdown in transportation, but if they were they would be able to flood the country with plates. In 1916 we produced a trifle more than 1,800,000 gross tons of sheared plates, quarter-inch and heavier. To-day we can produce very nearly twice that tonnage. If we were able to build steel ships at the rate of 500,000 deadweight tons a month, which we are very far from being able to do, we could supply all the plates required, meet all possible export demands, and still have a large surplus. Twelve months ago we were thinking of wooden ships as the only thing possible, but those easily possible, and nine months ago General Goethals' announcement that he was turning to steel ships, and had been promised the steel plates, started a controversy which it is unpleasant, but perhaps profitable, to keep in recollection.

It is difficult to correlate what we see. Everybody has a job and presumably everybody is working at it. Fuel Administrator Garfield stated in connection with his plant-closing order that production had outrun requirements, hence a little holiday could do no material harm. What is the work that is being done? The people have certainly decreased their consumption. There is very little building, except in connection with war work. Altogether, if we are really at work we should be producing more, along right lines, than we are. More production, with less consumption in ordinary peace activities, are the two material desiderata. Apparently we have them both, in very large measure, but the sum of the two items, which represents the war activity, should be large, very large, and yet it does not seem to be so.

It is clear, at any rate, that ordinary commercial activity has greatly decreased. "Business as usual" has been killed as a slogan, and very properly. Forces, ability to do things to help win the war, are released, but it does not seem that they are fully and intelligently employed.

Much regret has been expressed of late that things should come to light of a nature calculated to dampen our enthusiasm in "winning the war." That is not the philosophy of winning wars, however. As was said of discovering the North Pole, "It's dogged as does it." It is not national psychology that excitement and enthusiasm increase as war is carried on. That comes early. What wins is the dogged determination, directed by intelligence.

Two things in particular are requisite. There must be a better system at Washington as regards the placing and following up of orders, and there must be a restoration of rail transportation facilities. The reform at Washington is in progress. Matters have been brought to the light. The confusion and argument may be unpleasant, but it will bring results.

As to the railroads, our enemy was an unprecedentedly hard Winter, our ally will be Spring. Transportation conditions have been so bad, crippling sadly nearly all industries, that it has been easy to forget that before winter came, and that not so long ago, the railroads were handling a volume of traffic far in excess of anything ever before attained. Railroad facilities were inadequate, but they were doing much better than could have been expected in the circumstances. They will do still better in future. Spring will bring new life, and the epidemic of spring fever will be the lightest in a generation, thanks to Mr. Hoover!

Readers' Views and Comments

Advantages of Hydro-Electric Power

To the Editor of Metallurgical & Chemical Engineering

SIR:—All the large industrial plants at Sault Ste. Marie are running as usual under special exemption by Dr. Garfield and W. K. Prudden from their recent and drastic fuel orders. These plants are operated by electricity produced by water power from the rapids of the St. Mary's River. The Michigan Northern Power Company and Edison Sault Electric Company produce and distribute about 40,000 hp. from these rapids. This power is used to operate all industries of any size at the Sault, including the immense plants of the Northwestern Leather Company, Union Carbide Company and Soo Woolen Mills. There is now immediately available at the Sault about 1500 hp. which can be increased to 4500 upon very short notice and the installation of the type of machinery most efficient for the operation of any particular industry.

Under the present fuel conditions this available water power is of great economic advantage to manufacturers who are or may be embarrassed for lack of fuel, the supply of which is restricted to those industries which the government may designate as essential.

We know that this item will be of interest to your readers and will naturally be pleased to have it brought to their attention.

SAULT STE. MARIE CIVIC
Sault Ste. Marie Mich. AND COMMERCIAL ASSOCIATION.

Chemistry and the War

To the Editor of Metallurgical & Chemical Engineering

SIR:—It has been said that the present conflict is a war of chemists, and, to a very great extent, this is undoubtedly true. Never has artillery fire played so important a part in warfare.

The enormous tonnage of explosives required must by produced by the chemist. The chemist must produce also the materials for bombing and gassing, and he must furnish the fuels for ambulances, supply autos and aeroplanes. He must make the gun cotton for the war-head of the torpedo, and the high explosive for the depth bomb, the cement for concrete defenses and the gas masks for protection against the poisonous gas which the enemy chemist has produced. He manufactures many of the oils and concentrated foods used, and supplies the potash, nitrogen and phosphorus compounds used in the fertilizer necessary for the proper production of food stuffs. The khaki color which makes the soldiers' clothing inconspicuous in the field are also the product of his handiwork. He manufactures the numerous pharmaceutical products used in the hospitals and the sterilizing agents for the field water supplies.

The war has given a great impetus to the manufacture in this country of photographic developers, lenses, pharmaceuticals, synthetic perfumes, flavoring extracts, saccharin and numerous other products. Before the war, Germany and Austria supplied the world with the better grades of chemical apparatus and reagents. The United States bought many millions of dollars' worth annually of laboratory glassware. Since these importations automatically ceased we have been able to make our own glassware, which is now of a quality superior to that manufactured in Germany or Austria. We are also making an excellent quality of porcelain.

Before 1914 every pound of synthetic phenol came from Europe. Now a score or more plants are producing it in large quantities, chiefly for use in the manufacture of picric acid for war purposes. The September *Chemical Engineer* stated that the Edison works at Orange, N. J., is furnishing regularly 3,000,000 pounds of phenol per month.

At the beginning of the war, potash salts, for instance pearl ash, was selling at less than three cents a pound, and shortly after the price rose to $1.50 a pound, or more. Industrial establishments were obliged to use substitutes for all potash compounds or go out of business. Germany produced practically all of the potash at that time. To-day many methods are employed in this country to produce potash, some of which may well compete with the German products after the war.

Before the war, Germany made most of our colors used in textiles, leather, straw, feathers, paper, ink, pigments, varnishes, and for innumerable other products of our manufacture. At the present time we are ourselves manufacturing a quantity of color compounds equal to that used by us in normal times, and the number of colors produced is constantly increasing. Many concerns now manufacturing dyestuff intermediates have their own nitric acid, oleum, nitration, sulphonation, and acid-recovery plants.

With proper legislation we can manufacture on a competitive basis practically every chemical product which we now import. Cheap labor is not a factor of importance. The final selling price of the strictly chemical products imported into the United States annually before the war has been estimated by Gudeman (*Journal of Industrial and Engineering Chemistry*, February, 1915) at $250,000,000, of which not over four per cent represents labor value.

The tremendous advantage which Germany had at the beginning of the war has taken more than three years to counteract, and the result has been an awakening in other countries to the necessity of furthering the chemical and metallurgical industries in every possible way.

The Germans have for many years realized the grave necessity of furthering the work of the chemist and the chemical engineer for warfare, as well as for the necessities of industry in time of peace. They knew that by developing their enormous color establishments in peace times, they were producing factories which could be readily changed over to explosive works in time of war. They realized that the industries for the fixation of nitrogen used in fertilizers in time of peace could also be used for the production of enormous quantities of picric acid and trinitrotoluene in war time. They realized the necessity for acetone, synthetic phenol, industrial alcohol and all the numerous solvents and compounds used in peace as a still greater necessity for war.

The fact that strong corporations are entering the chemical manufacturing fields, indicates that capital

expects and feels a reasonable assurance that this country will properly further and sufficiently protect their interests after the war, in order that we may independently produce our own necessities and at the same time add new assets to the nation's wealth.

D. D. JACKSON.

Chemical Engineering Dept., Columbia University
New York City.

Precise Use of Figures

To the Editor of Metallurgical & Chemical Engineering

SIR:—I take the liberty of calling your attention to the extremely incorrect use of figures in the conversion table of Mr. Dwight Gerber in your issue of Jan. 15. In the example given, 5.5 lb. would be correctly expressed as 2490 g. But 5.5 lb. is different from 5.500 lb., for in the latter case the number of pounds is known to one-thousandth of a pound, while in the former case it is known only to the nearest tenth. This consideration shows the absurdity of converting 5.5 lb. to 2494.75835235 g. If 5.500000000000 lb. were converted to the number of grams given in the example there would be no criticism, but it is not very often that anything is weighed to this degree of accuracy.

M. DEKAY THOMPSON.

Cambridge, Mass.

Nickel-Chromium Wire

To the Editor of Metallurgical & Chemical Engineering

SIR:—The opinon seems to prevail to a certain extent, that the purchaser of an electric furnace employing nickel-chromium wire as its heating unit cannot secure a new unit with which to repair it when the wire burns out. We want to correct this erroneous impression.

It should be clearly understood that any concern or individual can buy units, in the form of coiled wire, having measured and definite resistance, with which to rewind any electric furnace built by a manufacturer licensed under the Marsh Patents. The user can purchase wire in this form and make the repairs himself.

These coiled units can be secured from the device manufacturer by giving him proper data, relative to the furnace to be repaired, such as Serial No., Type, Voltage, etc.

LICENSORS UNDER THE NICKEL-CHROMIUM RESISTANCE ELEMENTS PATENTS.

Laboratory Methods for Benzol-Recovery Plant Operation

To the Editor of Metallurgical & Chemical Engineering

SIR:—The following corrections and additions should be made to my article on the above subject published in your issues of Nov. 1, Nov. 15 and Dec. 1, 1917:

Method for the Determination of Light Oil in Gas.

Vol. 17, *No.* 9, *Nov.* 1, 1917, *pages* 550-551.

1. It is important that a complete blank test be run on the wash oil used. If the blank is high the oil should be thoroughly steamed out at a temperature of 160 deg. C. before using.

2. For passing gas through absorption apparatus, the rate of flow of the gas during the absorption should not exceed 2 cu. ft. per hour for benzolized gas, or 4 cu. ft. per hour for debenzolized gas.

3. In making steam distillation of oil from absorption apparatus, the temperatures given are in error. The oil should be heated until the temperature shows a temperature of 160 deg. C., and the temperature should be maintained between 150 deg. and 160 deg. C. throughout the steam distillation.

4. When testing unpurified water gas or other gas high in carbon dioxide, a tower of oxide and shavings is substituted for sodium hydroxide bottle in absorption apparatus (bottle No. 1, Fig. 1, p. 550).

The Analysis of Light Oil.

Vol. 17, *No.* 9, *Nov.* 1, 1917, *pp.* 551-555.

In Tables I and II, p. 553, under "Estimated by Method"—column headed "Benz. Lb." is in error and should read "Benz. C_6."

Method for the Boiling Point Tests of Benzols.

Vol. 17, *No.* 10, *Nov.* 15, 1917, *pages* 586-588.

The word internal was omitted in stating dimensions of diameter of vapor tube, so the third sentence in section headed "Flask" should read: "Half way up the side of the neck a vapor tube of not less than 5 mm. *internal* diameter," etc.

Sulphuric Acid Color Test for Benzol, Toluol, Solvent Naphtha, Etc.

Vol. 17, *No.* 11, *Dec.* 1, 1917, *page* 642.

The proportions of sulphuric acid and material to be tested are in error, and second sentence in second paragraph should read as follows:

"Sufficient concentrated (1.84 sp. gr.) sulphuric acid is put in to fill one-quarter of the bottle, and then twice as much of the material to be tested is added." The subsequent shaking and comparison are as stated.

Determination of Naphthalene in Oils.

Vol. 17, *No.* 11, *Dec.* 1, 1917, *pages* 646-647.

In making the determination of the free picric acid present, the quantity of benzol solution to be drawn from burette (page 647) is in error, and should be 1200

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F. W. SPERR, JR.

H. Koppers Co.,
Pittsburgh, Pa.

Causticizing Soda Liquors

To the Editor of Metallurgical & Chemical Engineering

SIR:—I am surprised to note the absence of comment on one or two slight mis-statements appearing in the article "Causticizing Soda Liquors" in your issue of November 15, 1917. The authors state that the Dorr devices were developed principally for use in the concentration of ore in which the carrying fluid has no value. They intimate that this is a detrimental feature in the use of the apparatus in the causticizing process. While it is true that the flotation process for ores has given the Dorr apparatus great prominence in the field of ore concentration, we must remember that the early development, and for many years the only development, of Dorr apparatus was in connection with the cyanide process in which the carrying fluid (gold-cyanide solution) is the valuable portion and the pulp is wasted. Here we have exactly the same condition as is found in causticizing plants. To those who have worked with filters and who have vainly attempted to produce "a small volume of weak wash liquor" it seems strange to find the filtration process so strongly advocated at the expense of a more simple and efficient procedure.

IVAN E. GOODNER.

Paradise, Calif.

Western Metallurgical Field

Selective Flotation at Eureka, Colo.

THE United States Smelting, Refining & Mining Company have purchased the Gold Prince property at Eureka, Colo., and since that time have conducted extensive experimentation on their complex sulphide ore, containing gold, silver, lead, zinc, copper and iron. Definite results have enabled their local manager, MR. M. H. KURYLA, to design and build a 500-ton unit of modern steel and concrete construction, illustrated in Fig. 1, and which will start operations in the spring.

The old Sunnyside mill was modeled along the conventional lines of using stamps for grinding, followed by amalgamating plates and a few tables to clean the overflow. The troublesome iron-zinc middling was later treated in Huff electrostatic machines. The difficulties that had been experienced in making a satisfactory separation between the zinc and the lead, demanded a search for a more efficient separation. This has been found in the selective lead flotation process now being tested in one of the old mills acquired with the property, and which has eliminated the necessity of the static treatment.

SUNNYSIDE 500-TON MILL

The ore will be crushed at the mine in two No. 6-K gyratory crushers, working in series; a 3-ft. x 10-ft. Sheridan shaking grizzly being used between the two crushers to sort out waste and to separate rock for tube mills. The crushed ore will be delivered to the new mill by a 16,000-ft. Trenton tramway, and weighed at the discharge terminal by a Merrick weightometer. There are three 1000-ton cylindrical steel storage bins from which ore is fed by pan conveyors to three 8-ft. x 6-ft. Marcy ball mills working in closed circuit with 6-ft. extra heavy Dorr classifiers. The Marcy discharge, approximately at 20-mesh, will be sampled by an automatic motor-driven sampler, which together with the other samplers in the mill will be actuated by a master clock. That ball mills are being installed in spite of the fact that 100 stamps were available from the Gold Prince purchase is significant of the outcome of the investigations concerning equipment to reduce the ore from 2^1_2 in. down to 20 mesh.

The fine grinding will be done in three 5-ft. x 14-ft. tube mills, using mine rock for pebbles, and one 5-ft. x 8-ft. ball mill. From present indications a considerable economy may be effected by using mine rock, which appears to be especially well suited for pebble grinding. The overflow of the tube mill classifiers will be amalgamated inasmuch as the tests indicate that quite a proportion of the free gold fails to float selectively with the lead. For the present stationary plates will be used.

The selective flotation of the galena, together with a majority of the gold, silver and copper, will be accomplished in one 6-cell, 18-in. minerals separation subaerated machine of the latest Australian bottom-drive type, and one standard 6-cell, 24-in. M. S. mechanical machine. The test-mill results indicate a very fair recovery of lead in the form of a concentrate assaying 65 per cent lead and 5 per cent zinc from a head containing 4 per cent lead.

The tails from the above lead machines will be floated in a 20-cell, 24-in. standard M. S. machine, in which a zinc concentrate will be produced assaying over 50 per cent zinc with less than 5 per cent lead.

Both concentrates will be passed over Wilfley tables, which will be mostly in the nature of pilots. A definite proportion of the final tail from the zinc machines will be passed over a Wilfley pilot table. To thicken the tailings two 40-ft. x 12-ft. Dorr tray thickeners will be used. The lead concentrate will be thickened in a 16-ft. x 8-ft. Dorr thickener and filtered in a 12-ft. x 3^1_2-ft. Portland filter. The zinc concentrate will be thickened in a 25-ft. x 8-ft. Dorr thickener, filtered in a 12-ft. x 9-ft. Portland filter and dried in an Argall dryer, the dryer being available from the old 100-stamp Gold Prince concentrator.

The mill is served by an outside incline track, while the more important floors will be served by electric platform elevators. The small amount of pulp elevating that will be required will be accomplished by means of air-lifts.

Technical Association of Pulp and Paper Industry Meets in New York

The third annual meeting of the Technical Association of the Pulp and Paper Industry was held at the Waldorf-Astoria in New York, Feb. 5 to Feb. 7. The banquet was held at the Hotel Astor on the evening of Feb. 6.

Tuesday afternoon was given over to a meeting of the executive committee and to conferences of chairmen of standing committees.

A general session was held Wednesday morning at which President Henry P. Carruth presided. At this session reports were made by the officers and standing committees, of which there are now fourteen covering all phases of the industry.

On Wednesday afternoon two separate symposia were

held, one on Acid Making and one on Engine Sizing.

At the symposium on acid making the milk of lime and tower system were thoroughly discussed. Mr. E. R. Barker, of Boston, Mass., one of the leading exponents of the milk and lime system, read an interesting paper on that system. Mr. G. D. Jenssen of the G. J. Jenssen Co., New York, presented the advantages of the tower system, chief of which he said was the lower temperature of operation and consequent higher absorption of SO_2. He said the heat of the milk of lime system was also especially objectionable in summer time. Mr. Clinton K. Textor of the Nekoosa-Edwards Paper Co., Port Edwards, Wis., read an interesting paper on some of the theoretical considerations involved. Others who discussed the subject were: P. A. Paulson, Kimberly-Clark Co., Neenah, Wis.; Martin L. Griffin, Oxford Paper Co., Rumford, Maine; H. R. Heuer, Wheat Paper Co., Petoskey, Mich.; S. E. Lunak, Interlake Pulp & Paper Co., Appleton, Wis., and H. F. Obermanns, Hammermill Paper Co., Erie, Pa. A more complete account of this session will be given in a later issue.

At the banquet on Wednesday evening, Judge Charles F. Moore acted as toastmaster, and speeches were made by Dr. Charles H. Herty, editor of the *Journal of Industrial and Engineering Chemistry*, and Arthur F. Sheldon, president of the Sheldon School of Business Science.

First Annual Meeting of Chemical Alliance, Inc.

The Chemical Alliance, Inc., was formally organized at its first annual meeting at the Hotel Biltmore, New York, on Wednesday, Feb. 6. About two hundred were present.

The meeting was opened at 10 a. m. by Horace Bowker, president of the old Chemical Alliance, which was a fertilizer committee exclusively, acting in an advisory capacity to the Government. Chairman Bowker reviewed the events leading up to the formation of the present alliance and the reasons for its inclusion of all chemical and allied industries. An account of this reorganization has been previously given in our columns. The Chemical Alliance, Inc., the present organization was formed on Dec. 4, as we have previously stated, to take over the work of the former Committee on Chemicals of the Council of National Defense. Chairman Bowker explained that the work is varied and complex, with respect to the different sections. The Acids Section has had to deal chiefly with problems of production for war purposes, as has also the Alkali Section. The Fertilizer Section, however, which is not directly engaged in producing war materials, has had to deal chiefly with internal problems in the industry, such as coal supply, etc. The organization as a whole is a group of allied industries to which the Government can go and get information on its problems. It has already helped the Government considerably and is ready to help now. When the war is over there will be just as pressing problems as there are at present.

Mr. Henry Howard, vice-president of the old Alliance, followed with a short speech, in which he said that the main problems were those of distribution, obtaining of raw materials and the furnishing of statistics to the Government.

Mr. Charles MacDowell, president of the Armour Fertilizer Works, and now acting in an advisory capacity to the War Industries Board, made a few remarks and urged the fullest co-operation between the Raw Materials and Statistical Divisions of the War Industries Board and the industries represented in the Chemical Alliance.

Chairman Bowker then said it was the controlling view of the present Board of Directors, elected at the organization meeting in December, that the Alliance should represent primarily producers, and no others at the present time. This is subject to modification by the directors at any time, as they have the authority, according to the constitution, to decide on the membership.

The secretary, J. Cameron Bradley, reported that 169 applications for membership had so far been approved. This number has now been greatly increased through further applications.

Mr. D. W. Jayne of the Barrett Co. offered a resolution that no action of the Board of Directors or of any committee shall be binding on individual members, without the consent of the members. The resolution was adopted.

The chairman said that the formation of a vegetable oil, fats and glycerine section was under consideration, as it had been requested by the War Industries Board.

After this preliminary general session the members were split up into their various sections for the election of section chairmen. The following were elected:

Acids Section—W. D. Huntington, vice-president of the Davison Chemical Co., Baltimore, Md.

By-products of Coal and Gas Section—D. W. Jayne, Barrett Co., New York.

Foreign Pyrites Section—A. D. Ledoux, New York.

Electrochemical Section—F. A. Lidbury, president of the Oldbury Chemical Co., Niagara Falls, N. Y.

Fertilizers Section—C. G. Wilson, Virginia-Carolina Chemical Co.

Miscellaneous Chemicals Section—A. D. Rosengarten, Powers-Weightman-Rosengarten Co., Philadelphia, Pa.

Alkali Section—J. D. Pennock, Semet-Solvay Co.

Domestic Pyrites and Sulphur Section—Charles MacDowell, president, Armour Fertilizer Works.

Dyestuffs Section—Election deferred as not enough members present.

The above selections were announced upon reconvening. Election of new officers of the Alliance then took place, which resulted in the election of the officers of the old Alliance, viz., Horace Bowker, president; Henry Howard, vice-president, and J. C. Bradley, secretary-treasurer. The meeting was then adjourned, but most of the Sections met at luncheon and made recommendations to their chairmen, the chairmen meeting at 3.30 p. m. in a general directors' meeting. (Section chairmen are members of the Board of Directors.) At this directors' meeting in the afternoon five directors at large were elected and matters of organization were taken up.

New York Sections of Chemical Societies to Meet

The New York Section of the American Electrochemical Society will hold a joint meeting at the Chemists' Club on Friday, March 1, with the New York Sections of the Society of Chemical Industry and American Chemical Society. An illustrated talk will be given on "A Chemist's View of the Native Industries of China," by H. K. Richardson.

Metallography of Aluminium

Preparation and Etching of Microsections

By ROBERT J. ANDERSON

RELATIVELY speaking, aluminium has been but little investigated in the metallographic aspect, at least not in any measure comparable with what has been done on iron and steel or copper and brass. It therefore appears safe to say that there exists no metallography of aluminium; references in the scientific literature are scattered and few. This condition appears to be very curious when the importance of the metal as a material of construction for engineering purposes is considered. There have been some comprehensive investigations of certain of the useful aluminium alloys[1] and of some not so useful, but as to the metal itself, i. e., commercial aluminium of say 99 and and over per cent Al, no thorough metallographic work has come to the attention of the writer. On the metal as such, the main work has been done by Brislee[2], while a late paper[3] promises information which should be valuable. Other miscellaneous and scattered data are available, but it appears that a metallography of aluminium is yet to be set forth.

Other than on the metallography of aluminium, there is still room for much work with this metal, as may be witnessed by the fact that one of its most important physical properties; viz., its density, required redetermination as late as 1911 (this work by Dr. Brislee). Knowledge as to the annealing of cold-rolled (partly amorphous) aluminium sheet is still rather vague, and accounts of tests in this regard would no doubt be appreciated.

On account of the large number of engineering uses to which aluminium is being put, it may be that the account in this article will be of interest. A technique for developing the internal structure of aluminium is not so easy as for iron or steel, brass or copper, which ordinarily engage the attention of the metallographic laboratory. Hence, special modifications of the usual metallographic methods must be employed if satisfactory results are to be secured. The present article describes methods for the satisfactory preparation and etching of aluminium microsections.

Pure aluminium when submitted for microscopic examination may be in the form of castings, cold-rolled or annealed sheets, slabs, bars, wires, shapes, etc.; in alloys, it may be in the same forms. As an alloying element, it may predominate or not; where it predominates, the methods hereinafter described for pure aluminium are in general satisfactory, but where it is subordinate to another metal, e. g., copper in copper-aluminium alloys (erroneously termed bronzes), methods and reagents for copper or copper-rich non-ferrous alloys are better suited. This article deals with the metallography of aluminium and its alloys where aluminium is the main constituent.

Preparation of Microsections.

The general plan of preparing a metallic microsection is about as follows: (1) selection and removal of a portion of convenient size; (2) grinding or filing a flat surface; (3) polishing that surface; and (4) development of the structure by etching. The ordinary methods of polishing steel microsections will not afford good results with aluminium. Aluminium being rather soft will flow under light pressure, and while a buffing or burnishing action will produce a high polish, which the metal readily takes, heavy pressure will cause blurring of the structure and even local surface hardening. This must of course be avoided.

If microsections from castings are to be examined, they are prepared by the ordinary methods, which are familiar to metallographers, but observing special precautions. When aluminium or its light alloys are polished on fine emery papers (French Hubert Nos. 0, 00, 000, 0000), the surface becomes very dark, in fact almost black; this darkening is ascribed to the emery particles working into the surface of the metal, and becoming embedded there.

A. G. C. Gwyer[4] has written as follows on the subject of polishing aluminium:

> The chief difficulty attendant upon the polishing of pure aluminium and its softer alloys is the trouble which is experienced with the retention in the polished surface of the metal of the emery from the finer grades of polishing papers, as it is practically impossible to remove it subsequently on the wet-polishing wheel. Professor Carpenter has obtained good results by the substitution of ordinary blotting-paper in the place of the final emery-paper, but the writer has never been able to achieve success with this method, and has, in fact, now abandoned dry polishing entirely. With the softest aluminium the writer has obtained excellent results following the procedure here given:
>
> (a) Fine file, kept thoroughly wet with paraffin oil.
>
> (b) No. 1 emery-paper, soaked in paraffin, on wooden board.
>
> (c) No. 2 emery-paper, soaked in paraffin, on wooden board.
>
> (d) Diamantine powder on cloth-covered polishing wheel, kept thoroughly moist with water and also maintaining the supply of polishing powder.
>
> (e) "Globe Metal Polish" on "selvyt" cloth, on polishing-board, rubbing lightly. It may be found on examination that there has been some appreciable surface flow, in which case it is necessary to revert to No. 2, or possibly even No. 1, emery-paper and repeat all the above operations. This does not, however, usually take very long to carry out, and only very light pressure with the hand is required. The final

[1] Carpenter, H. C. H., and Edwards, C. A., Eighth Report to the Alloys Research Committee: Aluminium and Copper; January, 1907.

Rosenhain, W., and Lantsherry, F. C. A. H., Ninth Report to the Alloys Research Committee: Copper, Aluminium and Manganese; January, 1910.

Rosenhain, W., and Archbutt, S. L., Tenth Report to the Alloys Research Committee: Aluminium and Zinc; April, 1912.

[2] Brislee, F. J., A Redetermination of the Density and Coefficient of Linear Expansion of Aluminium; Trans. Faraday Soc., Vol. VII, Part 3, June, 1912, pp. 221-228, with discussion by Seligman, *et. al.*

———, A Redetermination of the Elastic Modulus of Aluminium; Trans. Faraday Soc., Vol. IX, Parts 1 and 2, July, 1913, pp. 155-161.

———, The Density of Aluminium, *ibid.*, pp. 162-173.

[3] Carpenter, H. C. H., and Taverner, L., The Effects of Heat at Various Temperatures on the Rate of Softening of Cold-Rolled Aluminium Sheet; Paper before the Inst. of Metals (London), 1917; and in Eng'ing (London), Vol. 104, 1917, No. 8, pp. Metal Industry (London), Vol. IX, Sept. 28, 1917, No. 3, pp. 260-270.

[4] Hudson, O. F., Etching Reagents and Their Applications. Journ. Inst. of Metals, No. 1, 1915, Vol. XIII, pp. 193-221.

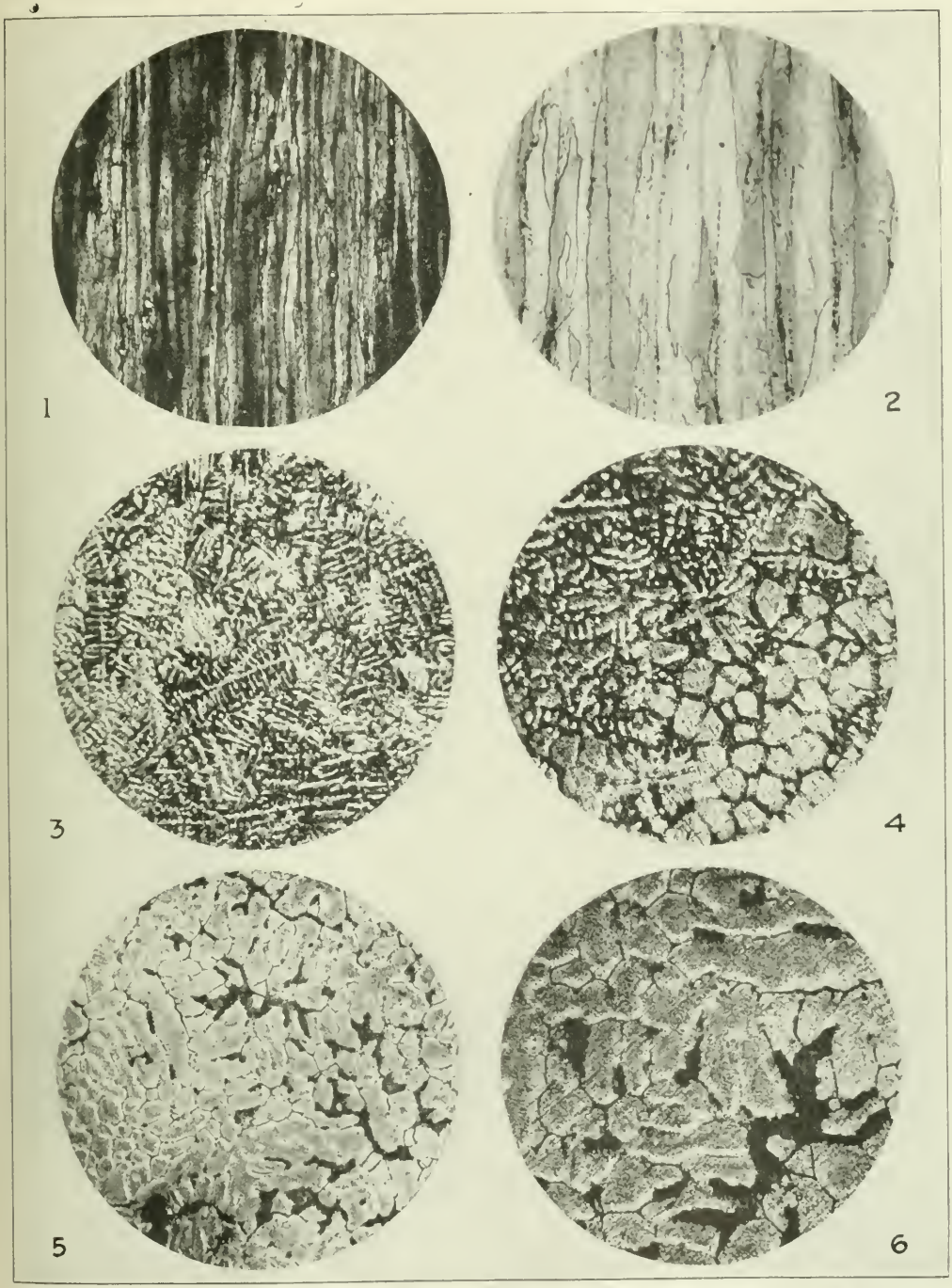

FIG. 1—Cold-drawn bar; 13 per cent Zn and 87 per cent Al; dark deposit resulting from etching with sodium hydroxide; X 150 diameters (after Rosenhain and Archbutt)

FIG. 2—Hot-rolled bar, 5 per cent Zn and 95 per cent Al; dark deposit resulting from etching with sodium hydroxide partially removed by weak chromic acid; X 150 diameters (after Rosenhain and Archbutt)

FIG. 3—Cast-pig aluminium; chill cast; X 40 diameters

FIG. 4—Cast-pig aluminium; similar to Fig. 3, but taken at a point a little further back toward the center of the pig; allotriomorphic grains and dendrites; X 40 diameters

FIG. 5—Sand-cast aluminium; microsection from gate; X 50 diameters

FIG. 6—Sand-cast aluminium, microsection from gate; X 100 diameters

polish before etching for metallographic purposes should be effected with a little metal polish on the finger, rubbing very lightly.

This method, advocated by Gwyer, is very good as anyone who may try it will find. As to the use of blotting paper[5], the writer has never had any success with this material, and supports Gwyer in his abandonment of dry polishing. A method somewhat similar to that of Gwyer, but possibly more rapid, has been developed by the writer, and it has given satisfactory results. This is as follows: preliminary preparation may be carried out by leveling off the surface of a massive section with a plain fine file followed by dry coarse emery paper and then by No. 0 French Hubert. This should be followed by Nos. 00, 000, 0000 French Hubert in succession, but these papers are covered with a thin layer of paraffin. The paraffin film prevents the entrance of the fine emery particles into the metal, and gives a high mirror-like polish.

The finer emery papers are covered with paraffin by simply pouring melted paraffin on their surfaces, and removing the excess with a flat, warmed instrument such as a dull knife or a three cornered file. The fine emery papers may either be secured to wooden boards or fastened to revolving discs. After polishing on the finest grade of paraffin-covered emery paper, this is followed by polishing on a duck-covered board or disc with fine tripoli and water in order to remove the No. 0000 scratches. The tripoli causes darkening of the surface, but this quickly vanishes when the final polishing is done on fine broadcloth or old well-washed calico with a good non-alkaline metal polish.[6] This may be followed or not by further polishing with No. 3 levigated alumina, or the alumina may be substituted for the metal polish as desired. The above procedure has been found satisfactory, but no doubt various modifications could be employed which would serve as well or possibly better.

Aluminium, being soft, is worn away very rapidly, so that the pressure or rubbing should be light. What amount of pressure to use is of course incapable of definition, but a comparison of the practice employed and the results obtained will determine how hard to rub.

When thin aluminium sheets are to be examined, it is more difficult to obtain a good microsection than in the case of castings or thick slabs. The gages usually submitted for microscopy vary from No. 10 to 28, and in the case of gages from 18 to 28 the thinness of the metal makes preparation troublesome. Sections may be prepared by cutting a strip about 0.75 inch square, bending up the corners slightly so as to afford a means of holding the piece, and polishing in the usual manner. In the case of highly planished cold-rolled sheets, the metal is stiff and hard and also has, as such, a high polish, so that complete following out of the procedure outlined, from file to alumina, may not be necessary; here the coarser grinding may be omitted, and only the two finest grades of paraffin-covered emery paper, the tripoli, and metal polish used.

Microsections of dead-soft thin-gage sheets are difficult to prepare because the metal bends so easily under the lightest pressure; it is therefore almost impossible to retain a perfectly flat surface even if it is once obtained. Small wires can be held in small clamps made of electrician's fibre, as in the case of other metals and alloys. It may be said that aluminium and its light alloys can be rapidly polished by hand, and very good results obtained by that means.

Other methods have been described for polishing aluminium, and Brislee[7] mentions rouge for final polishing. Rouge has never been found satisfactory by the writer; it causes surface darkening, and is therefore not recommended. Polished surfaces vary with polishing powder employed, as is well known[8]; thus silver when polished with rouge is darker in appearance than when polished with white alumina, and the same thing is true in comparing aluminium microsections polished with these two powders. The theory of polishing powders while interesting cannot be discussed here, but the facts in the case are that alumina is more satisfactory than rouge for polishing aluminium.

Etching Aluminium Microsections.

Aluminium and aluminium-rich alloys have been etched by the use of sodium hydroxide, hydrochloric acid, and hydrofluoric acid. Sodium hydroxide has been stated to be satisfactory for developing the structure of alloys of aluminium with zinc, copper, and manganese, but this reagent usually leaves the surface of microsections covered with a black deposit. On rolled and drawn material, this deposit will have a banded appearance. This deposit, according to Rosenhain and Archbutt[9], is of a carbonaceous nature and can be removed readily by immersing the microsection in a weak solution of chromic acid, after etching in sodium hydroxide. This is illustrated in Figs. 1 and 2 after Rosenhain and Archbutt.[10] Fig. 1 is a photomicrograph of an alloy containing approximately 13 per cent Zn and 87 per cent Al, in the form of a 13/16-inch cold-drawn bar; the dark deposit has been completely retained. Fig. 2 is that of an alloy containing about 5 per cent Zn and 95 per cent Al, in the form of a 7/8-inch hot-rolled bar; the deposit has been partly removed.

Ordinarily, satisfactory results may be obtained by the use of both sodium hydroxide and potassium hydroxide, if the black deposit is removed by chromic acid.[11] Sodium hydroxide is used in various strengths from 5 to 20 per cent. Ten per cent cold aqueous NaOH has been employed by Carpenter and Edwards,[12] with an average etching period of from three to five minutes. After trying sodium hydroxide, potassium hydroxide, hydrochloric acid, and hydrofluoric acid for etching a wide variety of forms of pure aluminium and many of its alloys, the writer is of the opinion that hydrofluoric acid is the best reagent. Hydrofluoric acid introduced by Brislee[13]; his reagent was made up by adding one part of fuming hydrofluoric acid to eight of water. When an aluminium microsection is immersed in this reagent, there is a steady evolution of hydrogen, and as the etching proceeds the surface becomes dark-

[5] Mentioned also by Dr. Rosenhain as being used at the National Physical Laboratory, England; private communication August 24, 1917.

[6] After trying a large number of metal polishes on the market a polish called "Magic Metal Polish" was found to be very good; its composition is not known.

[7] Brislee, F. J., *op. cit.*, p. 170.

[8] Rosenhain, W., Physical Metallurgy, 2nd ed., New York, 1917, pp. 26-27.

[9] Rosenhain, W., and Archbutt, S. L., *op. cit.*, p. 391.

[10] By permission of Dr. Rosenhain.

[11] This method was devised by S. L. Archbutt of the National Physical Laboratory, England.

[12] Carpenter, H. C. H., and Edwards, C. A., *op. cit.*, p. 254.

[13] Brislee, F. J., *op. cit.*, p. 170.

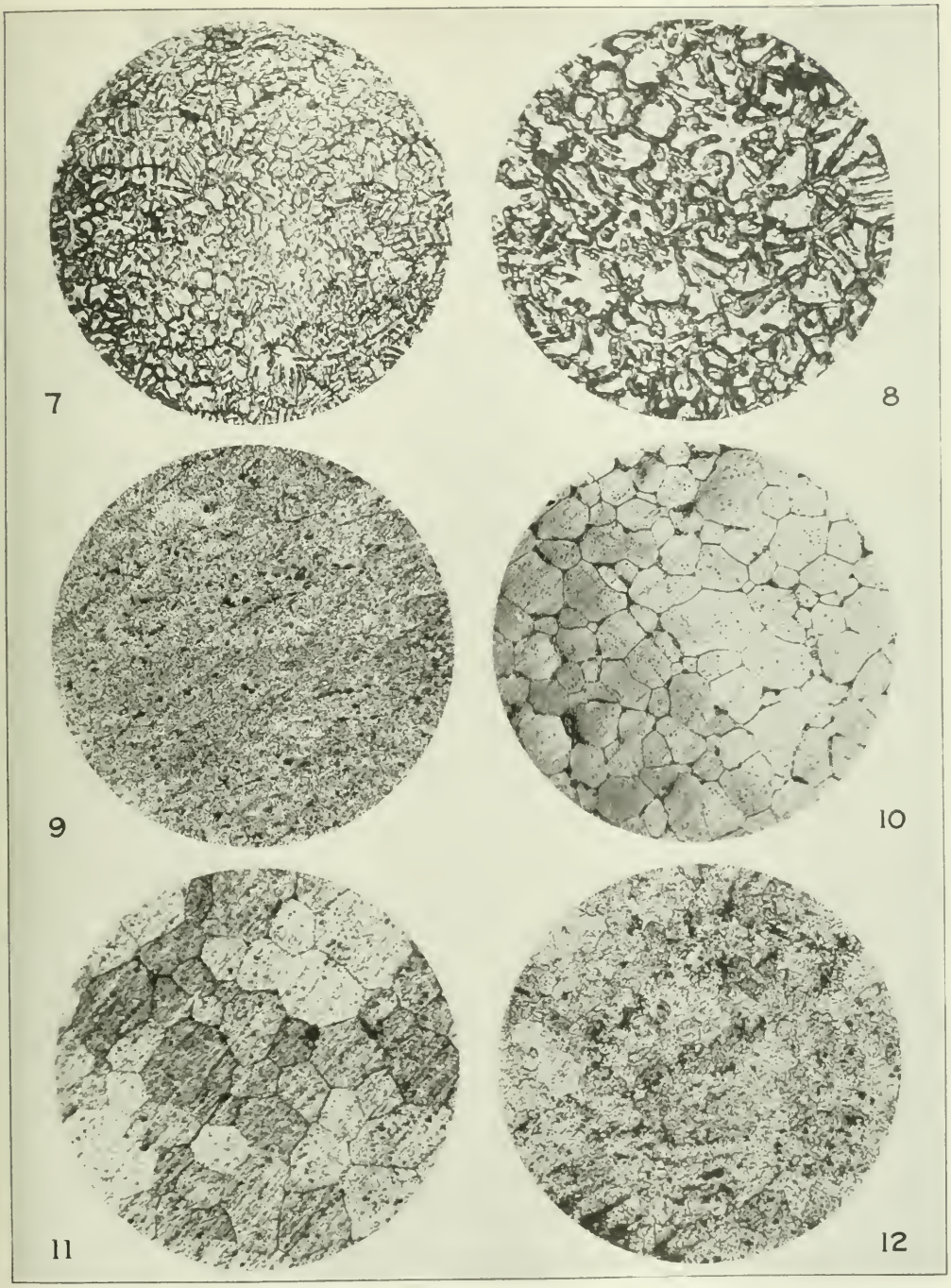

FIG. 7—Chill-cast aluminium; microsection cut from the center of a tensile-test bar (not ruptured) cast in an iron mold; X 50 diameters

FIG. 8—Chill-cast aluminium; same as Fig. 7 but X 100 diameters

FIG. 9—Hard-rolled aluminium sheet, 16-gage, probably mostly amorphous; X 100 diameters

FIG. 10—Aluminium sheet, in annealed condition, reorientation of grains. X 50 diameters

FIG. 11—Annealed aluminium sheet, 16-gage; X 100 diameters

FIG. 12—Hot-rolled aluminium slab, 0.25 inch thick; X 100 diameters

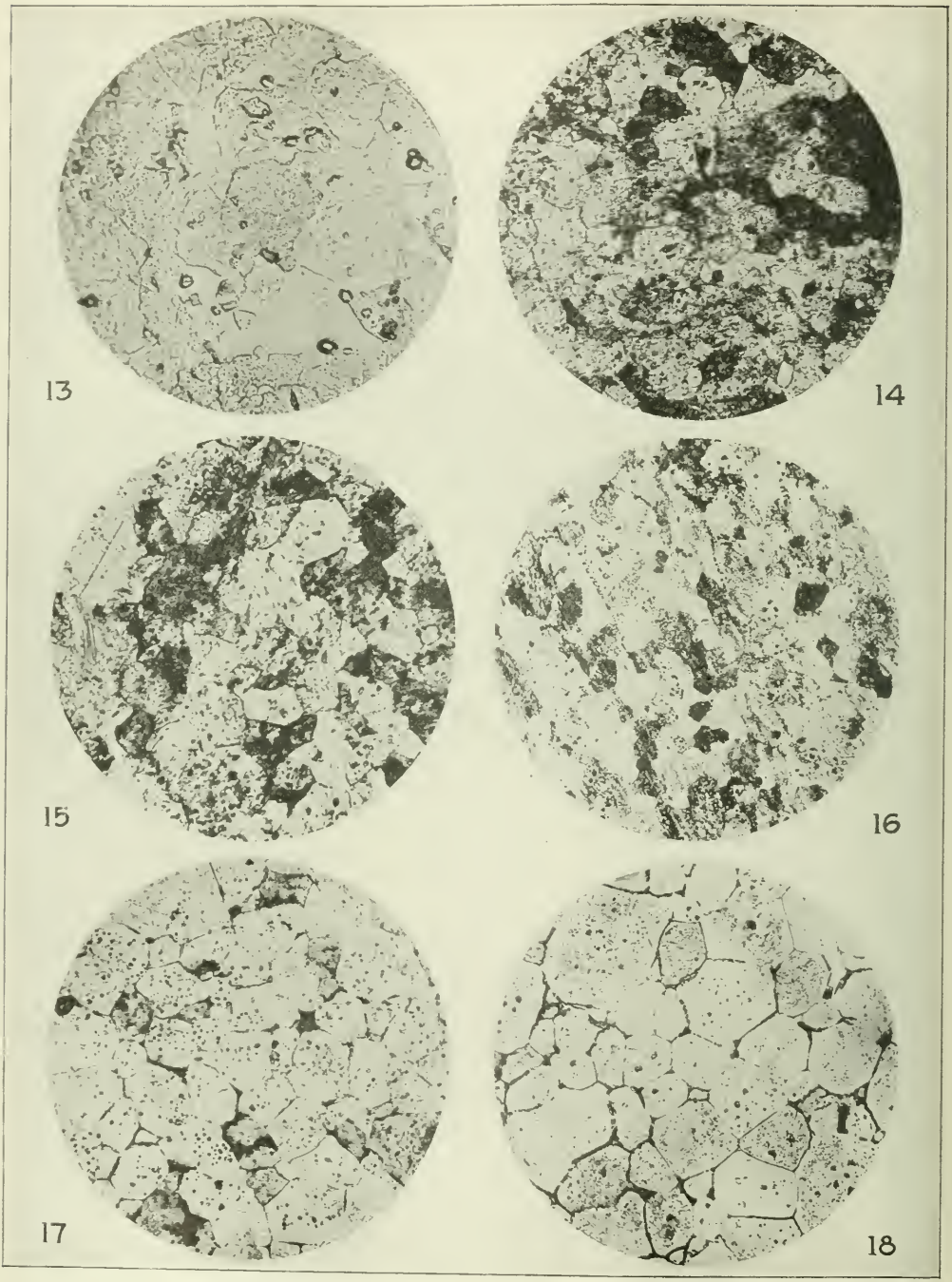

FIG. 13—Hot-rolled aluminium slab; same as Fig. 12, but X 215 diameters

FIG. 14—Annealed aluminium slab; same as Fig. 12 after an exposure of 10 minutes at 485 deg. C.; X 100 diameters

FIG. 15—Annealed aluminium slab; after annealing for 10 minutes at 540 deg. C.; X 100 diameters

FIG. 16—Annealed aluminium slab; after annealing for 10 minutes at 595 deg. C.; X 50 diameters

FIG. 17—Annealed aluminium slab; after annealing for 60 minutes at 595 deg. C.; X 50 diameters

FIG. 18—Annealed aluminium slab; after annealing for four hours at 595 deg. C.; X 50 diameters

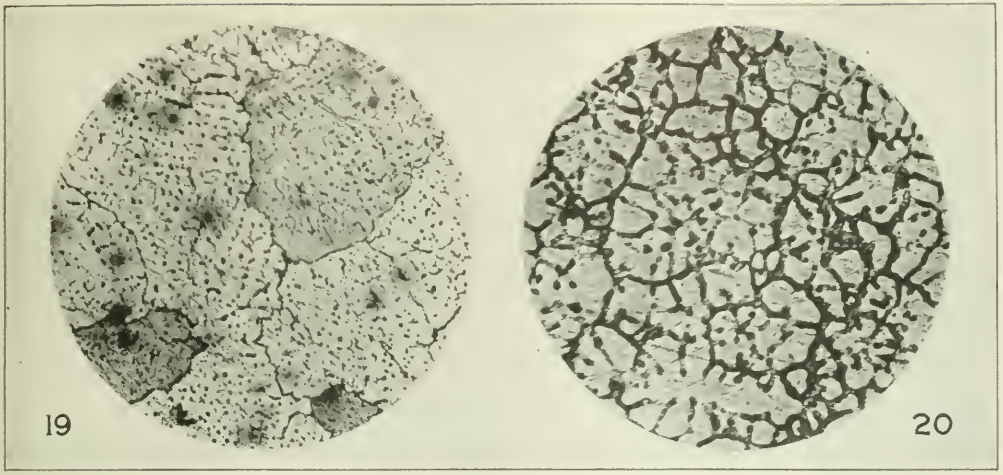

FIG. 19—Aluminium-copper alloy; 4.90 per cent Cu; cast in sand; X 50 diameters

FIG. 20—Manganese-aluminium alloy; 1.65 per cent Mn, chill cast; X 100 diameters

ened, but this darkening is readily removed by an immersion for a few seconds in strong nitric acid.

If a 15 per cent aqueous solution of hydrofluoric acid is used as the etching reagent (made by diluting the ordinary laboratory reagent with water), an etching immersion of about one minute will develop the structure of cast aluminium. The progress of etching may be inspected microscopically or under a low-power lens, and if the structure is not sufficiently developed, the microsection may be etched for a longer period. The questions of strength of acid and period of etching are so very variable that no definite rules can be laid down, nor does there appear to be any necessity for such. Various strengths of hydrofluoric acid may be employed, and the etching period will vary with the strength of the acid. The stronger solutions work more rapidly, and this is a factor in routine work or where a large number of microsections are to be examined.

For containing the hydrofluoric acid, a stock solution may be kept in a paraffin bottle; and for etching, a small amount, say 30 cc., should be poured into a paraffin dish or into a paraffin-coated dish. After etching, the surface of the microsection may be washed in water and then dried in alcohol and ether in the usual way. When properly etched, aluminium is silvery-white in color, and the internal structure may be readily seen under the microscope.

Microscopic Structure of Aluminium.

Photomicrographs in Figs. 3 to 20 inclusive show various forms of aluminium and two alloys; the microsections from which the photographs were taken were prepared and etched by the methods described. Fig. 3 is a photomicrograph of cast-pig aluminium which was poured in a chill mold; freezing was rapid, and the usual allotriomorphic grains typical of pure metals in general are absent; what are present are dendrites, the arms of which are fairly well defined, and which approximate in appearance the frozen ammonium chloride of Rosenhain.[18] The branches or arms from the various crystallization centers are interlocked. Water frozen in street gutters and on sidewalks has at times a like appearance. Fig. 4 shows a photomicrograph of the same metal at the juncture of the dendrites and the allotriomorphic grains (these being common to the interior of the pig); the transition from one structure to the other is marked. Fig. 5 illustrates sand-cast aluminium of high purity; it consists essentially of allotriomorphic grains of aluminium with the impurities segregated to the boundaries; the same thing is shown in Fig. 6, but at twice the magnification. The large black patches are not identified; they may be occluded matter.

Chill-cast metal is illustrated in Figs. 7 and 8; the microsection was taken from a tensile-test bar which had been cast in an iron chill mold. The arms proceeding from various centers of crystallization are very marked, similar to Fig. 3 but quite different from Fig. 5. In Fig. 9, there is shown the appearance of cold-worked aluminium sheet (16-gage), rolled cold from a slab about 0.25-inch thick. No evidence of crystallinity is apparent, and the metal is evidently mostly amorphous; flow lines in the direction of work (from left to right) appear to be distinguishable. The results of annealing cold-worked aluminium are shown in Fig. 10, which is a photomicrograph of annealed 16-gage metal. The difference between Figs. 9 and 10 is plainly evident. Fig. 11 also shows the effects of annealing on cold-rolled aluminium sheet. The degree of cold work in the case of the sheet represented after annealing by Fig. 10 had been greater than in the case of Fig. 11 because of the larger grain size of the former; both samples had been annealed for 15 minutes at 540 deg. Cent. and allowed to cool with the furnace.

When aluminium is hot-rolled, its appearance will be not unlike that in Fig. 12; there is still evidence of crystallinity but the grains have been distorted due to the work. Possibly some self-annealing took place on the metal in question, as the rolling was finished hot—at about 300 deg. Cent. The evidence of partial crystallinity in this metal is better shown in Fig. 13, at a higher magnification. The effects of annealing on the

[18] See Fig. 20, Plate VI, Physical Metallurgy, 2nd ed., New York, 1917.

hot-rolled slab, shown in Figs. 12 and 13, is illustrated by Figs. 14 to 18 inclusive. Metal shown in Fig. 14 had been hot-rolled to a 0.25-inch slab and then annealed for 10 minutes at 485 deg. Cent.; recrystallization is partial but far from complete. Fig. 15 shows the results of annealing the same metal at 540 deg. Cent. for 10 minutes; recrystallization is plainly not complete, but has proceeded further than in Fig. 14. The effects of annealing at still higher temperatures are shown in Fig. 16, where the slab had been annealed at 595 deg. Cent. for 10 minutes, and in Fig. 17, where the slab had been annealed at 595 deg. Cent. for 60 minutes. Hot-rolled aluminium after annealing at 595 deg. Cent. for four hours is shown in Fig. 18, where recrystallization is complete and grain growth has proceeded.

A photomicrograph in Fig. 19 shows the appearance of sand-cast aluminium-copper alloy containing 4.90 per cent Cu, and chill-cast manganese-aluminium alloy containing 1.65 per cent Mn is illustrated by Fig. 20.

Cleveland, Ohio, January 11, 1918.

Fuel Oil Now Under License

A proclamation has been issued by President Wilson placing under license all manufacturers and distributors of fuel oil with sales of more than 100,000 barrels a year. The system went into effect Feb. 11. Fuel Administrator Garfield has compiled a list of activities which will have the preference in receiving supplies of fuel oil. The distribution will be under the direction of Mark L. Requa, head of the Oil Division of the Fuel Administration.

Gasoline and kerosene are not included under the term fuel oil and hence do not come under Government control at present.

The list of preferred activities follows:

1. Railroads and bunker fuel.
2. Export deliveries or shipments for the United States Army or Navy.
3. Export shipments for the navies and other war purposes of the Allies.
4. Hospitals where oil is now being used as fuel.
5. Public utilities and domestic consumers now using fuel oil (including gas oil).
6. Shipyards engaged in Government work.
7. Navy yards.
8. Arsenals.
9. Plants engaged in manufacture, production, and storage of food products.
10. Army and navy cantonments where oil is now used as fuel.
11. Industrial consumers engaged in the manufacture of munitions and other articles under Government orders.
12. All other classes.

The chief reason for the placing in effect of the licensing system is the lack of adequate transportation facilities due to railroad congestion and the use of many tank cars for other purposes. It is also necessary that railroads using fuel oil have a sufficient supply and army and navy requirements must be taken care of.

It is also pointed out that many ships which are normally used for transporting fuel oil have been diverted for other purposes and this helps to make the transportation problem more difficult.

Depolarization by Sulphur Dioxide

By M. de Kay Thompson and A. P. Sullivan

THE following is an extension of the work by M. de Kay Thompson and N. J. Thompson,[1] on the electrolytic oxidation of sulphurous acid. In the former investigation the current efficiencies of the oxidation of sulphurous acid were determined; in the following the object was to determine how much the voltage is lowered at the anode by the presence of sulphur dioxide. The object in using sulphur dioxide as a depolarizer would be primarily to save power, only incidentally to make sulphuric acid; consequently the question here taken up is of greater importance than that in the first paper.

The electrolytic cell used consisted of a porcelain vessel in which a porous cup was placed as a diaphragm. The cell was placed in a cooling vessel. The inside diameter of the cup was 3.8 cm., the height 12.7 cm., when a platinum anode was used. For the duriron anode[2] a larger cup was necessary, 5.6 by 15.4 cm. A copper cylinder surrounding the porous cup formed the cathode. Anodes of platinum and of duriron were used. The platinum anode measured 2.5 by 8 cm., giving a total area of 40 sq. cm.; the duriron 5 by 11 by 0.5 cm,, giving a total area of 123.5 sq. cm.

The top of the porous cup was closed by means of a rubber stopper, through which passed the anode, a glass tube for delivering the sulphur dioxide below the anode, a tube for the exit of the excess gas, and another tube for making connection with the standard electrode for measuring the potential of the anode. The standard electrode was mercury covered with mercurous sulphate in one-tenth normal sulphuric acid. This was connected in the usual way to the liquid of the anode portion by means of an intermediate vessel containing saturated potassium chloride, to eliminate the liquid potential. This electrode was measured against a hydrogen electrode with twice normal sulphuric acid. According to Ostwald Luther (3d Ed., p. 445), the cell

$$Hg\ |\ Hg_2SO_4\ |\ sat.KCl\ |\ 2nH_2SO_4\ |\ Pt + H_2$$

would have the electromotive force 0.692 volt. The value measured was 0.663 volt. Therefore the standard electrode used had the single potential —0.663 volt, referred to hydrogen as zero, the charge on the solution giving the sign. All single potentials are here given on this scale. The current and voltage were measured by Weston portable instruments. The voltage of the cell which consisted of the anode and standard electrode was measured by the Poggendorff method with a Lippmann electrometer. A Weston cadmium cell was used for calibrating the bridge.

The sulphur dioxide was made by dropping concentrated sulphuric acid from a dropping funnel onto sodium bisulphite covered with a little water, in a 500 cubic centimeter flask.

The first runs were made as follows: A constant current was passed through the cell and the potential of the anode measured against the standard electrode for a period of 20 to 30 minutes, without sulphur dioxide. This was done for the whole range of currents used. Then a similar series of runs was made with sulphur dioxide passing through the anode compartment. When this potential became constant it was as-

[1] Met. & Chem. Eng., 15, 677 (1916)
[2] Kindly furnished by the Duriron Castings Co., Dayton, Ohio.

TABLE I—POTENTIALS OF SMOOTH PLATINUM ANODE, REFERRED TO HYDROGEN AS ZERO, IN 10 PER CENT SULPHURIC ACID, WITHOUT SO_2. TEMPERATURE, 17° TO 22° C.

1.25 Amp. dm²		2.50 Amp. dm²		3.75 Amp. dm²		5 Amp. dm²		7.5 Amp. dm²		10 Amp. dm²	
Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts
0	−1 005	0	−1 151	0	−1 168	0	−1 205	0	−1 259	0	−1 357
2	−1 135	2	−1 203	2	−1 207	2	−1 240	2	−1 348	2	−1 429
5	−1 138	5	−1 209	5	−1 229	5	−1 255	5	−1 374	7 5	−1 469
10	−1 154	9	−1 217	9	−1 240	11	−1 284	11	−1 400	11	−1 485
15	−1 163	14	−1 226	15	−1 254	15	−1 299	17	−1 410	17 5	−1 504
20	−1 180	19	−1 226	22	−1 265	21	−1 318	22	−1 415	22 5	−1 504
						25	−1 325				

TABLE II—POTENTIALS OF SMOOTH PLATINUM ANODE, REFERRED TO HYDROGEN AS ZERO IN 10 PER CENT SULPHURIC ACID WITH SO_2. TEMPERATURE 14° TO 17° C.

1.25 Amp. dm²		2.50 Amp. dm²		5 Amp. dm²		7.5 Amp. dm²		10 Amp. dm²	
Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts
0	+0 233	0	+0 183	0	+0 157	0	+0 090	0	+0 013
2	+0 221	2	+0 152	2	+0 113	3	+0 052	2	−0 028
5	+0 215	5	+0 140	5	+0 105	8	+0 035	4	−1 63
10	+0 212	11	+0 126	11	+0 091	13	+0 033	Depolarization	
15	+0 205	16	+0 122	17	+0 086	20	+0 017	ceases	
20	+0 205	25	+0 111	22	+0 082				
25	+0 202								

TABLE III—POTENTIALS OF SMOOTH PLATINUM ANODE, REFERRED TO HYDROGEN AS ZERO, IN 16.5 PER CENT $CuSO_4$, WITHOUT SO_2. TEMPERATURE, 13.5° TO 18.5° C.

1.25 Amp. dm²		2.50 Amp. dm²		5.00 Amp. dm²		7.5 Amp. dm²	
Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts
0	−1 196	0	−1 321	0	−1 517	0	−1 697
2	−1 246	2	−1 384	3	−1 584	2	−1 758
5	−1 265	8	−1 423	8	−1 611	8	−1 718
10	−1 281	13	−1 436	13	−1 612	12	−1 709
15	−1 289	19	−1 443	16	−1 612	15	−1 697
20	−1 301	22	−1 446				
25	−1 308						

TABLE IV POTENTIALS OF SMOOTH PLATINUM ANODE, REFERRED TO HYDROGEN AS ZERO, IN 16.5 PER CENT $CuSO_4$ WITH SO_2. TEMPERATURE 14.5 TO 15° C.

1.25 Amp. dm²		2.50 Amp. dm²		3.75 Amp. dm²		5.00 Amp. dm²		6.25 Amp. dm²	
Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts
0	+0 201	0	+0 113	0	+0 051	0	−0 003	0	−0 012
3	−0.192	3	+0.109	3	+0 044	2	−0 014	3	−0 039
6	+0 191	6	+0 104	6	+0 039	5	−0 005	6	−0 039
10	+0 188	10	+0 104	10	+0 034	10	+0 005	10	−0 032
14	+0 195	16	+0 103	16	+0 031	18	+0 042	15	−0 042
20	+0 193	20	+0 099	19	+0 033			18	−0 120
								20	−1 113
								Depolarization ceases	

sumed that the solution was saturated and that the maximum depolarization had been reached.

As the Tables I to IV show, runs were made with 10 per cent sulphuric acid and a smooth platinum anode, with current densities from 1.25 to 10 amp. per square decimeter. Above 10 amp. the dioxide did not depolarize the anode. With a 16.5 per cent solution of copper sulphate the platinum anode was not polarized at above 6.2 amp. per square decimeter.

These tables are summarized below:—

TABLE V—FINAL VALUES. SUMMARY
SMOOTH PLATINUM, 10 PER CENT SULPHURIC ACID

Current Density Amp. dm²		1 25	2 50	5 00	7 5	10
Potential of anode	Without SO_2	−1 180	−1 226	−1 325	−1 415	1 504
	With SO_2	+0 202	+0 111	−0 082	+0 017	−1 63
Depolarization		1 38	1 34	1 41	1 43	None

SMOOTH PLATINUM, 16.5 PER CENT COPPER SULPHATE

Current Density, Amp. dm²		1 25	2 50	5 00
Potential of anode	Without SO_2	−1 308	−1 446	−1 612
	With SO_2	+0 193	+0 099	−0 042
Depolarization		1 50	1 55	1 65

With smooth platinum there is therefore a reduction in the voltage of the anode of about 1.5 volts for both sulphuric acid solutions and for copper sulphate solutions, if a certain current density is not exceeded. This current density is between 7.5 and 10 amp. per square decimeter for sulphuric acid and is less than 7.5 amp. for copper sulphate.

This is not in agreement with the observations of Mr. M. R. Thompson,[3] who found sulphur dioxide ceased to depolarize at a current density of 3.23 amp. per square decimeter (30 amp. per sq. ft.), using a platinum-black anode in a solution of copper sulphate, sulphuric and sulphurous acid. When the dioxide ceased to depolarize the voltage increased by 1.5 volts, which agrees with our results, except in our experiments this did not take place at such a low current density. Also Mr. Thompson's single potentials are both several tenths of a volt more positive than ours; the differences between are not affected by this. It is possible the platinum-black electrode used by Mr. Thompson is the cause of the difference, though platinum-black would be expected to depolarize better than smooth platinum.

That the metal of the electrode does determine the current density at which depolarization ceases to take place is shown by the results with duriron, which are given in table VI.

In this table the results were obtained by a different method of measurement. The current given in the first column was applied for one-half minute, and the anode potential then read. The next current applied for the same time, and so on. A similar series was then made with sulphur dioxide.

TABLE VI—POTENTIAL OF A DURIRON ANODE, REFERRED TO HYDROGEN AS ZERO, IN A SOLUTION CONTAINING 10 PER CENT SULPHURIC ACID AND 16.5 PER CENT COPPER SULPHATE $CuSO_4$. TEMPERATURE, 12° TO 13°C.

	Without SO_2	With SO_2, Volts	Depolarization
Amp. dm²	Volts		
0 405	−1 46	−0 264	1 14
0 810	−1 510	0 359	1 15
1 22	−1 581	0 416	1 16
1 62	−1 62	0 471	1 15
2 43	−1 667	0 565	1 09
3 25	−1 707	2 073	None
4 05	−1 721		

If results could be obtained in practice as favorable as in these small scale experiments, it is evident that considerable saving would result from the use of sulphur dioxide as a depolarizer.

Massachusetts Institute of Technology,
Cambridge, Mass.

[3] Met. & Chem. Eng., 16, 178 (1917).

The Need for Organization in New Chemical Companies*

By FRANK HEMINGWAY

A MATTER that has been uppermost in my thoughts for the past year or so is the lack of organization in many of the new large chemical companies and the necessity of bringing order out of chaos before going much further with the present attempts to bring about nation-wide co-operative effort.

Nearly all of you here to-night are engaged in established and already highly organized industries, and would be apt to class as fairy tales a simple and unexaggerated statement of just a few of the things that have happened in the last three years and are happening to-day, particularly in an industry with which I have been in close touch for some time past, namely, that of the manufacture of coal-tar intermediates and dyestuffs.

Our visit yesterday to the wonderful plant of the Laclede Gas Light Company encourages us to believe that the manufacturers of coal-tar derivatives in this country have little or nothing to fear to-day, or after the war, in the face of world competition. But when we get to the next link in the chain—that is, eliminating the uses of the coke, the town gas and the sulphate of ammonia, and consider what is done with those products described as coal-tar derivatives—we must acknowledge, if we are to be honest with ourselves, that as regards the next two steps, first, the production of intermediates, and second, the manufacture of finished dyes, we are a long way from home.

We may look with just pride on the wonderful progress that has already been made, but to employ a business term, the real progress is decidedly "spotty."

Nothing in the development of an industry of national importance is such a handicap as wrong-minded public action, based on ill-informed public opinion, and I fear that the public generally, and indeed many members of the chemical profession itself, have based their opinion of recent developments on what they have read or heard of the successes made by those old established companies which have made a success and of one or two of the newer organizations which have succeeded.

They have not had presented to them the long list of failures, nor have they any idea of how close to the wind many of the newer chemical industries are sailing to-day, despite the price advantages they enjoy. It is interesting and extraordinarily instructive at this time to read carefully the history of the failure of the British dyestuff industry within a decade or so of the time of Perkin's discovery of mauve in 1856. The financiers and business men in those days blamed the chemist as being an impractical man, and claimed that what little success had been made was due to their own efforts as business men and to the work done by their engineers. The chemists blamed the financiers and the business men, and indeed everybody but themselves, and they all joined in one general condemnation of their government. But one fact stands out, namely: that the most important factor of all was, as I have already expressed it, wrong-minded public action based on ill-informed public opinion.

However, we may claim to an extent that through the work of some of the members of this Institute, and particularly of men like Dr. Charles Herty, the American public is much better informed today than was the British public in the sixties and seventies.

I shall not touch at any length upon that subject which is uppermost in the minds of the members of this Institute, namely, the ethics of the profession, beyond venturing to say, at the risk of making myself very unpopular, that a great deal has been done in the last three years without consideration to professional ethics and business honor. Capital has sunk many millions in enterprises on the advice of professional men who had nothing more than a book knowledge of the particular industry; and, as a consequence, capital today is not so entirely happy about the future of our great chemical industries as it would have been if all their advisers had governed their action by the code of ethics which this Institute has adopted; and although we have not caused these troubles, it seems to me that for the country's good we should do all in our power to correct them wherever possible.

Most of us have heard and used the expressions, "co-operation," teamwork," and so on, until we are heartily sick of them. It has been my experience that business associations are formed with great enthusiasm; the heads of the important companies are all present at the first meeting; the officers are elected; committees are formed; days are spent over the by-laws; much is said about co-operation, and then the big men hand the thing over to their juniors, and little further progress is made. We hear the same old platitudes and vintage bromides, and we know perfectly well that the same old competitive antagonism continues to a large extent.

Surely, the head of the biggest corporation in the world, Judge Gary of the United States Steel Corporation, realized this when he instituted the Gary dinner. There is nothing illegal or in violation of the Sherman Act about men becoming first acquaintances and then friends. What happens when competitors become friends? Not necessarily an illegal price agreement, but a full, frank, honest and open discussion of their common problems.

In the first year of the war such a coming together would have been impossible. Had it been possible there is no question that the aniline oil fiasco would have been avoided. Within an interval of a few months aniline oil dropped from exorbitant prices to less than cost.

I ask you, would men who through their friendships had gained some knowledge in advance of what was likely to happen, have deliberately entered the aniline oil business in those early days? Precisely the same thing happened in phenol.

*An address delivered at the St. Louis meeting of the American Institute of Chemical Engineers, December, 1917.

This kind of competition is the greatest of all business disasters. It results in the closing of plants, the freezing out of the small men, the profitable continuation of the operation of the concern that is financially very strong, and nine times out of ten, as a result of such a business upheaval, with its attendant casualty list, no true technical progress is made.

Our German friends met their problem in a very different way. If a German manufacturer found himself undersold, he concluded that in all likelihood one of two things had happened, either that his competitor had a better and more economical method, or was obtaining his raw material cheaper, and it seems to me that most of them never paused in their efforts to simplify, improve and cheapen their processes.

Now, as I said in the beginning, all this may sound elementary, even rudimentary, to those of you engaged in fully established and highly organized industries, but I want you to realize that tens of millions of dollars are invested in chemical industries in this country under conditions that amount to chaos, and I ask you is it right for us to view calmly the sacrifice of so much capital, so much plant, and so much human effort, even though it may have been ill-directed at the start?

Many of you may think I am drawing the long bow when I make the unqualified statement that I know of many companies of large size whose boards of directors are composed wholly of financiers and business men possessing no chemical knowledge whatsoever, and in which there is no co-ordination between the directing head, the chemists and engineers, or chemical engineers, the sales department and the purchasing department. Companies hear that there is a good and profitable market for a certain product, and after full discussion with their head chemist—who, of course, should be able to produce any chemical product whatsoever; indeed that is what he is paid for—decide to start the manufacture.

There are innumerable instances of large companies that in good faith have entered into contracts for the sale of products which their chemist told them they could produce, only to make cash settlements after months have passed, and the realization was forced upon them that they were unable to produce the goods with the technical knowledge at their disposal.

Yet such concerns blunder along from one mistake to another without taking the simple and obvious step of bringing about co-operation among their own departments and placing on their board the best and most highly trained technical men that they can find.

Surely a scrutiny of the directorate of the leading and successful German chemical companies would at least indicate to these gentlemen that the success of the German industries had to a large extent been brought about by the prominence given in the management of their affairs to men of scientific attainments. It is hard to believe that with such conditions of complete lack of co-ordination or effort under their very noses, in their own establishments, these very gentlemen will give time and thought to such matters as governmental action. It looks like getting the cart before the horse.

About two weeks ago I had the pleasure of entertaining Dr. M. O. Forster, technical director of British Dyes, Limited, and of bringing him together in a social and informal way with the heads of several of the important companies manufacturing intermediates and dyestuffs. Dr. Forster spent a month in this country studying the development of the industry here, and, as I understood him, with one thought in mind, namely, the future of the industry in America, in France and in England, and what was likely to happen after the war. He felt that in the fact that the countries of the Allies could not possibly produce a full line of dyes before the end of the war lay the great danger, for the Germans would sell their small tonnage specialties to American buyers only when the buyers purchased the full line. This condition is described in business as "full line forcing." There is a provision against this in the Clayton Act, and it seems that the crux of the whole matter will be in the enforcing of that provision.

It is evident, however, that some of the larger companies in this country are practising in their domestic trade the very evil against which they seek to protect themselves by legislation. We know of smaller concerns that are producing specialties that are of a better quality than the same product manufactured by the larger companies making a fuller line, but are unable to place them under contract because the buyers fear to split their business lest the larger companies keep from them their full line.

This in itself is a delicate situation, which I maintain would be avoided with advantage to all had all the manufacturers come in personal contact and acquaintance ripened into friendship and led to free discussion.

I fear I have wandered from my subject, which has to do simply with the lack of organization in some of the newer industries, but I could not resist the temptation of touching on these other matters.

To summarize the conclusions I have drawn from my observations in the last three years, I might say first that the members of such an influential body as the American Institute of Chemical Engineers should individually do all in their power to hold the confidence of the public, the business men and the financiers in the development of the newer chemical industries, and to offset as far as possible the damage that has been done by the action of professional men not qualified to advise on particular industries, but who nevertheless have not hesitated to involve large sums of money in development. Second, that for the nation's good the individual members of this Institute should do all in their power, and without regard to their own pecuniary advantages, to educate public opinion, the business men, and the financiers, to a correct understanding of the problems they face, with a view to bringing true scientific and technical order out of the chaos which exists in so many cases, and to make clear in fact to some of the more complex organizations that although the solution of one technical problem is important, it is more important to first perfect the co-ordination of all departments so that finances, business policy, scientific control, utilization of waste products, sales and purchases, work together as a solid unit to grapple and solve all problems presented.

115 Broadway, New York.

The Nichols Medal for 1917 has been awarded to Dr. Treat B. Johnson of the Sheffield Scientific School of Yale University. The presentation will be made on March 8, 1918, in Rumford Hall, Chemists' Club.

Efficiency in Industrial Research

By Charles W. Hill

THE establishment of many new industrial research laboratories in this country during the past two years, especially by concerns not directly connected with war products, will be noted with satisfaction by technical men. However, it is to be regretted that many of the older laboratories are not operating on a high plane of efficiency and that many of the newer ones have been started as experiments without due consideration of the experiences of the older organizations. The time appears to be ripe for a discussion of the various factors which influence the efficiency of industrial research, and for crystallizing the experiences of those who have been engaged in such work for some time, so that new laboratories may avoid the errors of the old and that the efficiency of others may be increased.

The following may be mentioned as among the more important factors: the relation of the laboratory to the general organization, the attitude and policy of the management, the selection of laboratory director, the selection of research men, problems and methods of work, and details of laboratory management.

Relation to the General Organization

The efficiency of a laboratory seems to be influenced in no small degree by its position in the general plan of organization of the company. The arrangement which is almost certain to give the best results constitutes the laboratory as a separate department occupying the same relative position in the organization as that of the production or sales departments, with the laboratory director responsible to the general manager. As a rule, the interposition of officials between the general manager and the director tends to lower the laboratory efficiency, although there appear to be exceptional cases where such an arrangement may not seem feasible.

A somewhat common and invariably a serious mistake is that of placing the laboratory under some branch or department of the concern. Frequently it is placed under the factory or production management. The idea back of such an arrangement is the fact that many if not all of the problems relate to the factory in some way or other. Experience shows that this is the very reason why the laboratory should not be under the factory management. It should be absolutely free from influence of a compulsory nature from any source, be it factory, sales or purchasing departments. Its success is attendant on the full co-operation with all branches of the organization; and this is best obtained when it is subject to none of them.

The attention of the writer was called to a large laboratory which is under the factory management, a large part of its time being devoted to rendering aid to a weak factory organization. Although the process is one of many years' standing, continuous help is required of the laboratory to maintain production, without the laboratory being allowed to make the changes necessary to place production on a firm basis. At the same time, each laboratory man is cautioned against breathing a word about actual factory conditions to anyone outside the factory management. If this laboratory were independent of the factory, it could soon bring about the desired changes in factory affairs. The benefits thus to be derived by the company as a whole, by the factory and by the laboratory, are obvious. The position of this laboratory in the general organization prevents it from doing good where it is most needed.

Attitude and Policies of the Management

The attitude and policies of the management regarding the laboratory are naturally of the utmost importance. Some managements expect a laboratory to be an immediate source of profit to the company. They sometimes expect wonderful and profitable results within a very short time and with a relatively small expenditure. As a rule, this can not be. It would be a sad commentary on the factory and technical men who have been in the business many years if a research laboratory could uncover startling discoveries regarding an old process in a short period of investigation. If money-making discoveries are possible with a small expenditure of time and money, every research man in the country would be experimenting on his own account in his cellar or attic if he could not afford a better place. Barring virgin fields, industrial research does not, as a rule, bring immediate results commensurate with the cost. It is therefore necessary for ultimate success that the general management foster research generously and wait a reasonable time for returns. One may possibly secure some profitable returns within two or three years after a well equipped laboratory is in full swing. Industrial research resembles mining. One must clear away the site, get down to the ore and get the machinery running before our mine will pay a dividend. The pay-dirt is seldom on the surface.

A niggardly policy in the matter of securing apparatus for efficient work and of paying salaries necessary to engage and retain men of quality results in inefficiency and unsatisfactory returns. This does not mean that one should go to the other extreme of unlimited expenditure and no accounting of progress to the general management. Any fair-minded director stands ready at any time to take the responsibility for his methods and expenditures, provided he is given authority over them; but he cannot successfully direct research if he is required to fight for each piece of apparatus or every increase in salary for his men.

A rather generous policy regarding the men in the laboratory is usually productive of the best results. This applies to such matters as working conditions, of hours, vacations and clean, healthful laboratories and offices, the publication of papers not of secret value, financial assistance to men attending meetings, etc.

The Selection of Director

The selection of a director is a vital matter in the establishment of a laboratory, and it is one in which a company can easily make a mistake. A common error is to transfer a chemist or engineer from routine or factory work into research work as a director. Another mistake is the selection of a man who has made a reputation in individual research but who has not had experience in working with or directing the work of others.

The personality of a director is of importance sec-

ond only to proper training and research experience. A director should be a good judge of men and able to manage as well as to inspire them. He should be a leader rather than a driver. Furthermore, he should be a man who is inclined to be independent and not in the least fearful for his own position. This enables him to present the requirements of the laboratory to the management and if necessary put up a good fight to carry through those matters which he knows are important. Being certain of his own standing, he can allow credit to fall on the men under him, taking his own credit for the harmony and general efficiency of the laboratory as a whole. Since his men look to him for advancement, he must be able to judge the merits of the individual and his work and not be influenced by "taffy" or design.

Selection of Research Men

As a general proposition, it is cheaper and more satisfactory to engage experienced research men than to train novices. A successful organization consists of experienced research men in charge of the various divisions of the laboratory with younger and less experienced men as their assistants.

The personality of the research man is of great importance. Men should be chosen carefully, and all should be on a kind of probation basis, especially with reference to their attitude and their ability to fit into the organization. Men who do not mix well with the others, who start dissension, who "blow" or "bluff" or who are confirmed "knockers" should not be retained on the staff. Good laboratory spirit and teamwork is of inestimable value and unfortunately is not always found in industrial laboratories.

In engaging new men, it is better to pay them the salary they ask if it is not unreasonable and to impress them with the necessity of demonstrating their self-appraised worth than force them to accept a lower salary than they feel they deserve. When true merit is involved, the greater returns due to proper spirit of the worker and his aim to make good will more than balance the difference in salary.

Problems and Methods of Work

The nature of the problems to be investigated by a particular laboratory will naturally depend on the extent of fundamental information in possession of the company regarding its process and products. Usually a new laboratory finds many problems of a practical nature awaiting solution. Factory problems as a rule give the laboratory a higher percentage of positive results than do other classes of problems, and hence they afford greater opportunity for returning a good profit to the company for the minimum of effort. However, it is a serious mistake to limit a laboratory to such problems. A certain proportion of men should be engaged with problems of a fundamental nature which carry the investigator into new fields. Such work is the most probable source of new processes or products which can be protected by patents and which protect the company against future competition in its field. Where necessary for the complete understanding of a practical problem, it is profitable to carry a certain amount of theoretical experimentation. There are those who argue for a complete separation of the two kinds of problems, even going so far as to maintain entirely separate laboratories. This would seem to the writer to be a rather arbitrary division and usually not to be advised. It is often highly desirable for the man on a practical problem to conduct theoretical experiments for some time, and it is often as desirable, if not necessary, for the experimenter on so-called pure research to follow the practical applications of his discoveries. It is difficult to see any reason for the attempted division. A well organized research laboratory has its analytical division which can be made large enough to handle the necessary control work for the factory, and there is a distinct advantage in having the control laboratory free from the factory.

There is no good reason for the objection of some investigators to so-called practical problems other than the fact that they frequently lead to results which cannot be published on account of their commercial value. There is, however, a serious objection to the manner in which some managements desire such problems to be handled. Regardless of the nature of the problem, scientific methods of research should be applied with smallest practical amount of the cut-and-try variety of research. Here is the place where officials have been known to interfere with the laboratory to the detriment of research and with loss to the company. It is an interesting although unpleasant fact that some managers, who would unhesitatingly swallow whatever medicine a physician prescribes, will attempt to prescribe methods of research to technical men of far greater comparative training and experience than possessed by the physician. Regardless of the nature of the problem, suitable equipment should be provided and proper methods of research should be followed.

Processes developed in the laboratory should be expanded to a semi-factory basis before final adoption in the factory. When they are finally placed on a factory scale they should be operated for a time by the laboratory before the regular production department takes charge. A division of responsibility or the introduction of research problems into the factory in this connection is likely to cause trouble.

Details of Laboratory Management

Cost Accounting

In all laboratory work fairly accurate records should be kept of the cost of time and materials. This enables the management to control the amount expended on any problem, and at the same time gives the laboratory credit for time spent on factory troubles and consultations which would otherwise be charged to research. There are three common methods of laboratory accounting. According to the budget system, the management appropriates a sum of money to cover all research expenses for a given period and makes the director responsible for the distribution of the total appropriation among the various problems. Frequently a separate appropriation is made for apparatus. The appropriation system is the budget system applied to individual problems, each problem being granted a sum of money and being assigned a time limit. When either the time or the money has been used, a further appropriation is required before the work progresses. According to the third system, accurate accounts are kept of the cost of each of the more important lines, and the monthly expenses of the laboratory are distributed among the various accounts. The manage-

ment may then urge expansion on some problems or the curtailment. The particular method of financing the laboratory does not seem to have any great effect on its efficiency, as long as the proper apparatus is supplied as needed, and as long as some accounting system is used.

OUTLINING OF WORK

Regardless of the experience of the individual worker, it is always advisable to have his work outlined in advance. This is not only better for him, but it affords a reliable record for patents in the case inventions arise from the work. Two systems commonly used are the Conference System and the Proposal System.

In the former, the subject of a research is discussed in a regular weekly or monthly conference among men from the laboratory, factory and patent department; stenographic notes being taken of the discussion. Results are presented by the research man and further work is planned by the conference. There are several objections to the system, of which may be mentioned the loss of time through arguments and futile discussions, the difficulty of directing discussion and of reaching a clear-cut decision, the loss of time in consideration of hastily made suggestions, and the feeling among many research men that the system removes personality from their work. Even the best conducted conference system is likely to follow the research more than direct it. This system alone does not appear to be as satisfactory as the combination of it with the proposal system.

According to the latter plan, a proposal for research is made by the research man and approved by the director. This consists of an outline showing the object of the proposed work, a reference to the previous work leading up to it, a statement of the principle or theory involved, an outline of the variables to be studied together with tests and methods. This outline may be made after conference with the director and others interested in the problem. When the proposed work is completed the results are summarized and further proposals made. Conferences are held when the research man is in need of suggestions as to methods of attack or of information from certain departments. Suitable arrangements are usually made for handling small problems and rush jobs without a proposal; but if such work involves much time or expense it should be outlined. An experienced investigator usually outlines his work and so does not object to submitting his outline for record. Some inexperienced research workers have been known to object to the proposal system and have urged that they be allowed to proceed without direction. This would obviously be dangerous for them as well as for the laboratory.

REPORTS

Reports should be carefully and completely written, and as their volume increases, abstracts and cross references should be made. The amount of useful data which can be buried for years, duplicated or misapplied because of faulty reports is often as surprising as it is disheartening. The cost of properly recording a piece of research so that it will be of value in future years is usually an insignificant part of the total cost.

Industrial research eventually pays and pays liberally if properly executed. It not only assists in raising the quality of a product and in lowering the cost, but it is the source of new products, new applications of old products, and of improvements and inventions which safeguard the future of an industry. It benefits the sales department by furnishing technical information and it inspires in the sales force a confidence in the leadership of their firm. It is a necessity in a modern business of magnitude, and has proved its worth even under unfavorable conditions. Its greatest possibilities are attained only under the proper conditions of management and surroundings, some of which have been outlined in the above discussion.

Pittsburgh, Pa.

Explosives and Ingredients Requiring Licenses

The Bureau of Mines has issued a list of articles requiring licenses under the Act of Congress prohibiting the manufacture, distribution, storage, use and possession in time of war of explosives and ingredients thereof. The list follows:

Explosives

Ammonium nitrate.
Blasting powder.
Caps:—Blasting, detonating, percussion—all classes.
Detonating fuse, or cordeau detonant.
Detonators.
Dynamites.
Electric blasting caps and electric detonators.
Fireworks and flash-light powders.
Fulminates.
Fuse of all varieties.
Gun cotton.
Gun powder and gun powder mixtures (except small arm or shot gun cartridges).
Nitro cellulose and nitro glucose.
Nitro glycerine (except in official U. S. Pharmacopoeia solution, or in form of pills, or granules containing not more than 1/50 grain each).
Nitro-glycol, -mannite, -starch, and -sugar.
Permissible explosives.
Ammonium picrate.
Picrates.
Picric acid.
Smokeless powder (except small arms and shot gun cartridges).
Trinitrotoluol.
Trinitrocresol.
Trinitronapthaline.
Tetranitroaniline.
Tetranitromethylaniline.

Ingredients

(List approved Jan. 5, 1918)

The purchase, possession, sale or use of anyone of the ingredients herewith listed below in amounts of *one ounce or over* requires a Federal Explosive License.

Bichromates:—Ammonium, potassium, sodium.
Chlorates:—Barium, potassium, sodium, strontium.
Chromates:—Ammonium, barium, calcium, chrome green, chrome yellow, lead, potassium, sodium.
Nitrates:—Ammonium, barium, copper, ferric, lead, magnesium, nickel, potassium, silver, strontium.
Nitric acid:—Aqua fortis, fuming, nitric acids of all grades and strengths, mixed acids.
Perchlorates:—Perchloric acid, potassium.
Perborates:—Magnesium, sodium, zinc.
Permanganates:—Calcium, potassium, sodium.
Peroxides:—Barium, calcium, magnesium, oxon (cubes and cartridges), sodium, strontium, zinc.
Phosphorous.

Licenses may be obtained from local federal licensing agents. Application must be made in person by duly authorized officers of companies. The licensing agent for New York is J. R. Healy, Municipal Bldg., and for Brooklyn, John F. Dixon, 365 Jay Street, Brooklyn.

The Third Annual Lyons Fair will be held March 1 to 15, 1918, at Lyons, France. The first two were held in 1916 and 1917 and were very successful. No American companies participated in 1916, but in 1917 thirty-three concerns were represented. This year a much larger representation is expected. Mr. George B. Van Cleve, 1790 Broadway, New York, is chairman of the American Committee.

Grain-Size Measurements

By Zay Jeffries

MANY grain-size determinations by the method described by the writer, A. H. Kline, and E. B. Zimmer* have led to certain refinements in manipulation. Of the several methods tried, the following is recommended as the most satisfactory:

A circle 79.8 mm. diameter is drawn on the rough side of a ground-glass screen, the center of the circle being near the center of the rectangular section of the screen. This ground glass is mounted in a frame which fits a metallographic camera, the smooth side of the glass being on the outside. When the image of the specimen for grain-size determination is focused on the screen the circle will be plainly visible and its circumference should be well within the image.

When the image is properly focused the grains intersected by the circumference of the circle are checked and counted. Since the check marks must be made on the smooth side of the glass, a soft red pencil such as is used in laboratories for marking beakers and flasks will be found satisfactory. The marks used to indicate the boundary grains are usually short, straight lines intersecting the circumference of the circle and perpendicular to it. The completely included grains are next checked and counted, after which the red marks are erased from the glass with a dry cloth. The specimen can then be moved and other measurements made as desired. The idea of putting the rough side of the ground glass with the circle drawn on it to the inside of the camera was suggested by W. T. Burgoon.

In the early experiments the equivalent number of whole grains within the circle was obtained by adding 0.6 of the boundary grains to the completely included grains. The factor 0.6 was used as the result of about 200 determinations which showed an average factor of 0.58. The accuracy of the work involved did not justify the use of a factor of two figures, so 0.6 was chosen in place of 0.5.

I am pleased to state that further careful measurements show that the factor 0.5 is actually more nearly correct than 0.6. The factor 0.5 is more convenient to use, since the boundary grains (usually less than 50) can be divided by 2 instead of multiplied by 0.6. It is true that either factor gives results somewhat more accurate than a specimen can be sampled and in some cases more accurate than the grains can be distinguished, but we now have experimental justification for using the more simple factor.

*Trans. A. I. M. E., Vol. LIV, pp. 594-607. The author's method is recommended by the American Society for Testing Materials, *Proceedings*, Vol. XVII, 1917, Part I, Tentative Standards.—Editor.

TABLE I

Magnification Used = m	Diameter of Circle in Millimeters	Multiplier to Obtain Grains per Square Millimeter = f
Full size	79.8	0.0002
10	79.8	0.02
25	79.8	0.125
50	79.8	0.5
100	79.8	2.0
150	79.8	4.5
200	79.8	8.0
250	79.8	12.5
300	79.8	18.0
500	79.8	50.0
750	79.8	112.5
1000	79.8	200.0
1500	79.8	450.0
2000	79.8	800.0

The use of the factor 0.5 in place of 0.6 does not in any way affect the use of the table of multipliers from which to obtain the number of grains per square millimeter at any given magnification. If the equivalent number of whole grains within the circle measured at a certain magnification be multiplied by the number in the third column of Table I opposite the magnification used, the product will be the number of grains per square millimeter.

A circle 79.8 mm. diameter has an area of 5000 sq. mm. If it is desired to use a rectangle in place of a circle for the determination, convenient sizes will be found in Table II.

TABLE II

Convenient Sizes of Rectangles for Grain-Size Determination

70.7 x 70.7 millimeters	55 x 91 millimeters
65 x 77 millimeters	50 x 100 millimeters
60 x 83.3 millimeters	

Since each of these rectangles has an area of about 5000 sq. mm., the multipliers given in Table I can be used for any of the rectangles in Table II, or any other rectangle having an area of 5000 sq. mm. To make a grain-size determination, with a rectangular in place of a circular area, the grains intersected by the periphery of the rectangle should be counted, one-half the number added to the completely included grains and the result will be the number of equivalent whole grains within the rectangle. If the determination is made at one of the magnifications given in Table I, the number of grains per square millimeter can be obtained by multiplying the equivalent number of whole grains within the area by the multiplier (f) opposite the magnification used. The rectangle could be used on a ground glass as described above for the circle or it could be used on a micrograph.

Brass metallographists do not use the magnifications given in Table I, so a separate table would be necessary for their purposes. Also, some metallographists prefer to refer to the grain size in terms of the diameter of the average grain in millimeters or the area of the average grain in μ^2. The following simple formulas will be found helpful in these cases.

w = boundary grains.
z = completely included grains.
x = equivalent number of whole grains in 5000 sq. mm. (circle 79.8 mm. diameter or rectangle having area of 5000 sq. mm.).
m = magnification used.
f = multiplier to obtain grains per square millimeter
n = number of grains per square millimeter.
d = diameter of average grain in millimeters.
a = area of average grain in μ^2.

$$x = \frac{1}{2} w + z$$

$$f = \frac{m^2}{5000}$$

$$n = fx$$

$$d = \frac{1}{\sqrt{n}}$$

$$a = \frac{1{,}000{,}000}{n}$$

Cambridge, Mass.

Some General Aspects of Evaporation and Drying*—II

By Hugh K. Moore

(*Concluded from page* 133)

Phenomena in an Evaporator Tube

THERE is a limit also to the amount of evaporation which can be done in a tube in comparison to the volume of liquor circulating through the tube. Generally speaking, the economical operation of such evaporation is limited to that point where incrustation on the tubes due to evaporation commences. It may be asked why this point should arise, or why an evaporator should be run in such a way as to approach this limit, when we know that as we approach it we add operating and mechanical difficulties to those which we already have in sufficient abundance. The answer is that unfortunately some liquors have such foaming tendencies that no way has yet been discovered to evaporate them without conducting the operation in such a manner as to make this point of vital importance. As an illustration it might be said that the writer had designed, built, and operated evaporators with tubes 2 in. in diameter and 7 ft. in height, and in which the liquor inside the tube rises only 3 in. above the bottom tube sheet. These levels, of course, were measured before steam was turned on and ebullition commenced. Foam, in the sense as used in evaporation, may be considered as a globule of vapor surrounded by a film of liquor. By keeping the level of the liquor low in the tubes the unbalanced pressure on the liquor entering the tube is reduced. The foam formed in the bottom part of the tube rushes up through the hot tube, and part of the fluid in the films is evaporated, thus increasing the relative amount of vapor and decreasing the amount of fluid. A point is reached where the volume of vapor is so great as compared with the volume of the remaining liquor that this liquor can no longer stretch as a continuous film about the vapor, and its separation may be accomplished. There is an all-too-common fallacy that increasing the height of the steam dome over a foamy liquor will decrease the foam. It cannot be done in this way, and a little consideration of the principles involved will convince the most skeptical of the fact. If the height of the liquor in the evaporator is increased the volume of the bubbles is decreased by the static pressure, according to Boyle's law, which, as the temperature is constant, may be written $PV = C$, where P is the pressure, V is the volume, and C is a constant. Then the volume of the bubbles is inversely proportional to the absolute pressure. If the static head is sufficient, the heat transmitted through the tubes may be absorbed in the liquid at a low zone without the liberation of vapor. As the liquid travels upward the static pressure becomes less, until at a certain point vapor can be liberated; this vapor constantly increases in volume until the surface is reached. It is evident from the above that increasing the height of the dome above the heating surface only changes the zone of the foam but not its quantity.

The height of the liquor above the tubes may in some cases be a very important and in some cases a controlling factor. For example, let us consider a case in which the liquor reaches a state of saturation for one ingredient long before the desired concentration of another ingredient is obtained. Such an example might be, for instance, the concentration of a solution containing both caustic soda and sodium chloride. Here, as evaporation proceeds, salt is precipitated, while the caustic soda remains in solution. Now, these sharp crystals of salt at a high velocity exert an abrasive action on the tubes.

Chart 7 is submitted principally for the purpose of illustrating this point. The conditions assumed for the calculations of this chart are: the evaporation of water alone under a vacuum of 6.35 in. mercury, boiling taking place at 212 deg. under 7.5 ft. static head, diameter of tubes 2 in., length of tubes 7 ft., thermal coefficient chosen more or less arbitrarily as 300 B.t.u. per square foot per degree Fahrenheit, average temperature difference of exchange 10 deg. Fahr. No account is taken of the increase in conductivity due to increased velocity.

An examination of this graphic shows that so long as the static head is sufficient to keep the heat in the water instead of forming steam there is no change in the velocity of the liquor in the tube, viz.: with a static head above the tubes of 7.5 ft. of water the velocity is about 0.65 ft. per second, and this is the same for 8.5 ft. static head of water. If, however, there is a static head of only 1 ft., the velocity of liquor entering the tubes is 7 ft. per second, and the velocity of the mixture of steam and liquor leaving the tubes 10 ft. 4 in. per second. Now, let us apply this to the caustic soda illustration, remembering that this chart is only illustrative of water, and that the values would be different for caustic soda, but that the underlying principles are the same.

Where heat is transmitted to the caustic, but steam is not formed, the salt remains in solution, and it is only upon the transformation of the water into steam that the salt is deposited. If this transformation takes place in the tube, the salt is deposited in the tube, and at the high velocity shown exerts an abrasive action on the tube which increases toward the top of the tube owing to the increased velocity. This velocity may, in some cases, reach the proportions of a continued explosion.

In the other case, where the liquor is not transformed into steam in the tubes, it circulates upward until finally as the static head is reduced to the limiting value steam is liberated above the level of the tubes entirely and the salt is deposited where there are no tubes to cut out. Now, much of this salt can be settled out, and what remains travels through the tubes at such a low velocity that it has no cutting action.

The writer has seen many tubes cut off at the top due to the explosive action of steam and salt, while the middle and bottom of the same tubes would show only the slightest wear.

Compare Chart 8 with Chart 7. The only difference in the conditions is that in Chart 8 the tubes are 4 in. in diameter instead of 2 in. The effect of decreasing the velocity is apparent, and needs no further comment.

The shape or surface of the tube may, in some cases, be the controlling factor. Thus, if a corrugated tube is compared with a smooth tube of the same size and of

*A paper read at the St Louis meeting of the American Institute of Chemical Engineers, December 7, 1917.

the same material, it will be found that at low velocities the thermal coefficient of the corrugated tube is greater than that of the smooth tube. At high velocities the reverse is the case. With the corrugated tube the maximum thermal coefficient is reached quickly, and at higher velocities may remain constant or even drop. While the writer's data on this point is, unfortunately, not complete enough to warrant graphical presentation, he has never yet found such a maximum conductivity in a smooth tube.

Calculation of Temperature Differences

In the design of evaporators one of the necessary factors employed in the calculation is the mean temperature difference. Chart 9 shows graphically the varying conditions one may have. Fig. 1 shows a condition where there is a hot medium imparting heat to a cold medium flowing either direct or counter current, and yet no change in the temperature of either. In other words, the temperature difference at any point in the flow is equal to the mean difference. An example of such a condition would be found when one had melting ice in contact with one side of a partition and saturated steam on the other side.

Figs. 2 and 3 are examples in which the temperatures of the media change, but the temperature difference remains constant. A concrete example would be a counter-current exchanger in which the hot liquid entered at 80 deg. and left at 60 deg., and the cold liquid entered at 40 deg. and left at 60 deg. In all of the above cases it is a very simple matter to get the mean

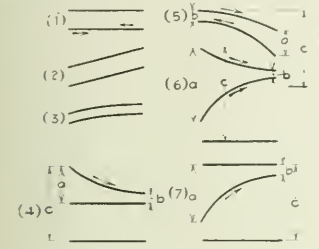

FIG. 9

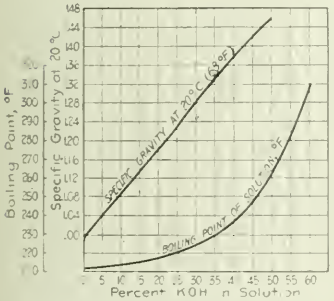

FIG. 12

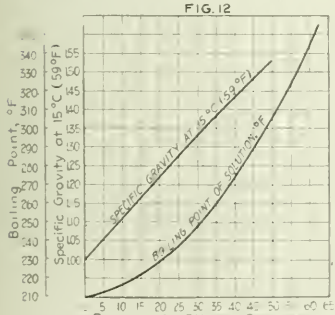

FIG. 14

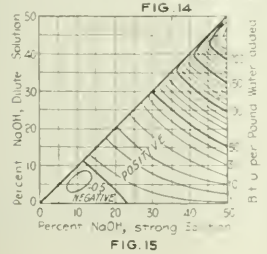

FIG. 15

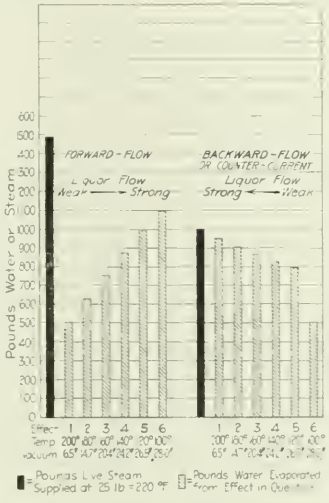
Pounds Water or Steam
FORWARD-FLOW
BACKWARD-FLOW OR COUNTER-CURRENT
Liquor Flow
Weak → Strong
Liquor Flow
Strong → Weak
Effect 1 2 3 4 5 6
Pounds Live Steam Supplied at 25 lb = 220 °F
Pounds Water Evaporated from Effect in Question

FIG. 10

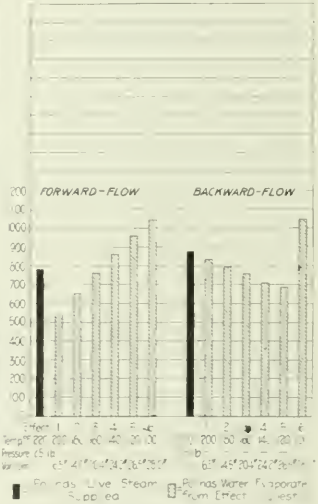

FIG. 11

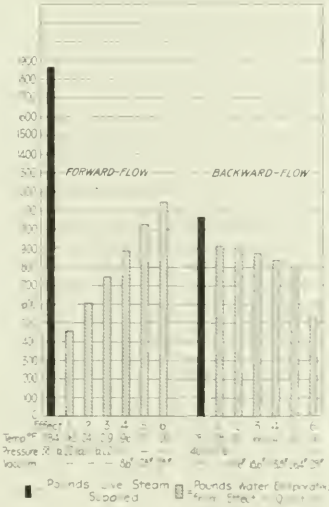

FIG. 13

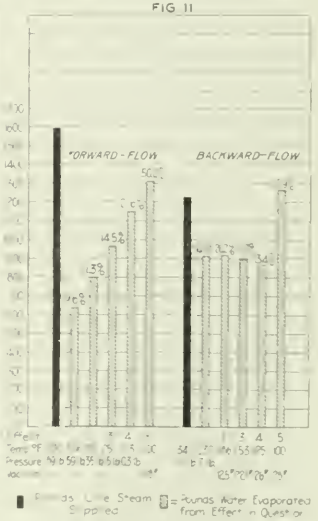

FIG. 16

temperature difference. But in the case of Fig. 4, when the cooler medium is at constant temperature and the warmer medium changes in temperature, as in the example of hot water being cooled by ice or a liquid at boiling point, the mean temperature difference can only be determined in a more complicated manner.

Fig. 5 shows a counter-current conduction example in which the temperature of one medium changes faster than that of the other; such, for instance, as would be the case if the specific heats were different, or if the volumes flowing in unit time were different.

Fig. 6 applies to a parallel-flow exchanger in which the conditions might be as above, with the exception that the fluids flow in the same direction.

Fig. 7 applies to a case in which one fluid changes in temperature by receiving heat from another which does not change in temperature. Such an example would be heating water with steam.

Hausbrand has already developed this subject at some length in his admirable treatise entitled "Evaporation, Condensing, and Cooling Apparatus"; and so it need not be repeated here. Hausbrand has, however, made the subject appear more complex than it really is. Chart 9 is simply Hausbrand's formula simplified. If (a) is the greater temperature difference of exchange and (b) the lesser temperature difference of exchange, then the true mean difference, commonly called the "logarithmic mean," (Lm), may be found by the formula

$$Lm = \frac{a - b}{\log_e \frac{a}{b}}$$

This formula would, of course, not be used for the simple cases of Figs. 1, 2 and 3, of Chart 9. The logarithmic mean in the other cases may vary from the arithmetical mean by amounts ranging from zero to more than 25 per cent, depending on the ratio of the lesser difference of exchange to the greater difference of exchange.[1]

Types of Multiple-Effect Evaporation

We have mentioned herein in a general way the conditions which more or less determine the type of evaporation which shall be followed in a given case. We have not, however, taken into account the fact that there may be varying conditions in the same type of evaporation. In multiple-effect evaporation, for instance, we may follow two distinct and separate procedures.

They are first, forward-flow, the arrangement in which the liquor and steam enter the first effect and the resulting vapor, condensed steam and stronger liquor go toward the last effect; second, backward-flow, or counter-current flow, in which the steam enters the first effect and the resultant vapors and drip flow toward the last effect, while the liquor enters the last effect and is pumped from effect to effect until it emerges concentrated from the first.

In the following illustrative charts the results are only correct to the limit of slide rule accuracy. No allowance has been made for loss of heat by radiation, inasmuch as the amount of this loss can be practically eliminated, if one wishes to do so, by putting on a sufficient insulating covering of the right character. The value of the charts will be found in comparison, and as we have several variables to consider, effort is made to illustrate them in order.

Forward-Flow and Backward-Flow

Suppose we have a solution weighing 5854 pounds, containing 8.54 per cent, or 500 pounds, of solids which have a specific heat 0.5. The liquor enters the system at 32 deg. and we are allowed 20 deg. difference of temperature exchange in each effect. The problem is to concentrate this weak liquor to a 50 per cent solution in six effects. In order to study, as far as possible, one variable at a time, let us assume in this problem that concentration does not materially raise the boiling point. Chart 10 shows that to evaporate this liquor, starting at 32 deg. Fahr., by the forward-flow method, approximately 1490 pounds of live steam are required from the boiler as against 1000 pounds of live steam required by the backward-flow or counter-current method. The next feature to be noticed is that while by the forward-flow method the evaporation increases as the pressure diminishes from effect to effect, in the backward or counter-current flow the evaporation diminishes as the pressure diminishes. In either case the temperature and pressures are the same. In the forward-flow method there is the loss of heat in the extra 490 pounds of condensed steam at 120 deg., equivalent to 43,120 B.t.u., and the loss of heat in the additional 590 pounds of steam at 190 deg. Fahr., equivalent to 651,960 B.t.u., which is lost to the condenser from the last effect. It will be seen that the great loss in heat in the forward-flow is through the condenser; in backward-flow operation much of this heat is utilized in heating up the liquor. In forward-flow operation the cold liquor, instead of being heated by waste heat, so to speak, is heated by live steam.

In the foregoing problem we have assumed that the liquor enters at 32 deg. Fahr. Chart 11 shows the calculated results of a problem in every way identical with the first, with the exception that the liquor enters at 160 deg. Fahr. instead of 32 deg. Fahr. In this case we find that it is more economical of steam to use forward evaporation. Forward evaporation requires 786 pounds of live steam, while backward or counter-current evaporation requires 882 pounds of live steam. Here there is a direct economy of steam in the forward method, to say nothing of the elimination of the necessity of pumping the liquor backward from effect to effect. In forward evaporation the amount of steam saved is not only that which would have been necessary to heat the liquor from 32 deg. to 160 deg., but also the additional saving due to losing less heat in the drip, *i.e.*, as the additional steam required in the other case, after being condensed, carried away a large amount of heat, the saving of this steam also saves this waste. If, however, the evaporation is backward, this heat is lost through the condenser in the steam from the last effect. As we are considering a six-effect system, the saving of live steam by forward-flow operation will be roughly one-sixth of the steam lost through the condenser plus the corresponding saving in the drip.

Having now briefly considered a liquor the concentration of which causes no material rise in the boiling point, let us consider a lquor in which the boiling point

[1]Since writing the above, I find in the November number of the *Journal of American Society of Mechanical Engineers*, a very interesting article by Howard M. Ingham on this subject. He shows an ingenious method of finding the logarithmic mean graphically.

rises markedly on concentration. Chart 12 shows the boiling points of solutions of caustic potash at different concentrations, and Chart 13 illustrates the evaporation of 5854 pounds of an 8.54 per cent caustic potash solution to a 50 per cent solution. In these calculations the specific heat of the caustic potash is taken as 0.5, as in the preceding problems, not because that is correct, but in order not to introduce another variable. This small error makes no fundamental change in the chart. It will be seen that in Chart 13 there are all the general characteristics of Chart 10. The input of steam in forward evaporation has increased nearly 25.5 per cent, while the input for backward evaporation has increased only 6.5 per cent. In forward evaporation the output of steam to the condenser has increased nearly 4.6 per cent, while with backward evaporation it has increased 3.8 per cent. Here, then, there is a large difference in steam input and very little difference in the steam output to the condenser. It will be readily seen from these charts that this difference is mostly due to the increased temperature of the final condensed steam, and the resultant theft of heat.

Temperature Differences

A study of this chart will also show that the other losses of heat in forward evaporation are greater than in backward evaporation. It is not within the scope of this paper to go into the losses of heat by convection to the air, so I will simply confine myself to comparisons, with the general statement that the greater the difference of temperature between similar bodies and the surrounding air the greater will be the loss of heat by convection.

The temperature of the live steam space with forward evaporation is 284 deg., while that of the corresponding space in backward evaporation is 287 deg., a difference of 3 deg. in favor of the former. The temperature of the liquor spaces are 264 deg and 267 deg. respectively, still a difference of 3 deg. in favor of the former. The temperatures of the steam domes are 263 deg. and 218 deg., a difference of 45 deg. in favor of backward evaporation. In the steam spaces of the second effects we have the same temperatures as in the steam dome of the first effects, with a consequent difference of temperature of 45 deg. Table A embodies these comparisons for the whole six effects. It will be seen from the table that there is a total of 6 deg. in favor of forward evaporation and 750 deg. in favor of backward evaporation, or net 744 deg. in favor of the backward evaporation, an average of more than 40 deg. between corresponding effects.

Pressure Differences

Now, as the temperature controls the pressure, it is perfectly logical to place on the same chart the corresponding pressures. While giving the columns of corresponding pressures, it will be noticed that the column of differences is omitted. The reason is obvious. Whereas a substantial excess of pressure on the liquor over that of the atmosphere may be the determining factor as to whether an evaporator can be run efficiently or not, a difference of vacuum practically makes no difference as far as the mechanical operation is concerned. Thus, suppose we had a solution of caustic potash and potassium chloride; a pressure on the caustic effluent might so fill the discharge nozzles with salt, due to the rapid formation of steam at atmospheric pressure, that the operation would not be feasible because of the danger of accidents.

The successful operation of most evaporators requires the use of one or more peep-hole glasses in order that the attendant may be able to watch for foaming tendencies, etc. Now, these sight-glasses, if they are under pressure may either break or crack, and the liquor may blow out into the operator's eyes; there is also the theoretical possibility of the glass itself blowing into his eyes. If, however, a vacuum is maintained, any such breaking or cracking of glass will be inward and the direction of the fluid will be away from the eyes and not toward the eyes.

TABLE A

Effect	Compartments.	Temperature. Forward.	Temperature. Backward.	Temp. Diff. Favoring Forward.	Temp. Diff. Favoring Backward.	Pressures. Forward	Pressures. Backward.
1	A	284	287	3	.....	38 Pressure	40 Pressure
	B	264	267	3	.....	22 Pressure	2 Pressure
	C	263	218	.....	45	22 Pressure	2 Pressure
2	A	263	218	.....	45	22 Pressure	2 Pressure
	B	243	198	.....	45	11 Pressure	10.6 Vacuum
	C	241	191	.....	50	11 Pressure	10.6 Vacuum
3	A	241	191	.....	50	11 Pressure	10.6 Vacuum
	B	221	171	.....	50	2 Pressure	18.6 Vacuum
	C	219	166	.....	53	2 Pressure	18.6 Vacuum
4	A	219	166	.....	53	2 Pressure	18.6 Vacuum
	B	199	146	.....	53	8.6 Vacuum	23.8 Vacuum
	C	196	143	.....	53	8.6 Vacuum	23.8 Vacuum
5	A	196	143	.....	53	8.6 Vacuum	23.8 Vacuum
	B	176	123	.....	53	17.8 Vacuum	26.4 Vacuum
	C	170	121	.....	49	17.8 Vacuum	26.4 Vacuum
6	A	170	121	.....	49	17.8 Vacuum	26.4 Vacuum
	B	150	101	.....	49	28.0 Vacuum	28.0 Vacuum
	C	100	100	.....	0	28.0 Vacuum	28.0 Vacuum
	Totals			6	750		

A = Heating-steam Space.
B = Liquor Space.
C = Evaporated Steam Space.

In the above caustic potash example, owing to the flatness of the boiling-point curve at the lower concentrations, nothing has been said about the heat of chemical combination with water, or heat of dilution, though this factor was considered in making the calculations. The effect is small, however, so that it does not materially affect the elements of the chart. The object sought was to show the results which must follow an increase in the boiling point during concentration.

Heat of Combination with Water

Let us now consider the effect of the heat of chemical combination of the solids with water. Unfortunately there does not seem to be any good illustration of a case in which there is not a perceptible change of boiling point also brought about by dilution. However, if the preceding illustrations are well understood, there should be no difficulty in understanding this variable. One calculation could be made neglecting the heat of chemical combination and another taking this factor into consideration, but the first would be so far from the truth that a comparison of the two results would not only be of no value but would actually be misleading.

It is well known that there are many substances which dissolve in water with a marked rise in temperature; such, for instance, are sulphuric acid, hydrochloric acid, ammonia, and caustic soda. Now, it is apparent that

if these substances give up heat when added to water, they must likewise absorb heat when separated from water. If this were not so we should have perpetual motion. Now, the data obtainable on this subject is not in the form which lends itself to the calculation of evaporator problems. The first thing, then, for one to do who has a problem in which the heat of chemical combination is an important factor, is to take his data and reconstitute it so that it shall be in convenient form. This may be done much in the same manner as a civil engineer makes a contour map from data of elevations and distances. He connects all points of equal elevations at whatever distances they may happen to be and one is then able to determine the elevation of any particular point by interpolation between successive contours.

Chart 14 gives the relation of boiling point to concentration of caustic soda solutions and Chart 15 is a "contour map" of the heat of dilution of caustic soda solutions expressed in B.t.u. per pound of water added, concentration being changed between known values. Thus, suppose a 40 per cent caustic solution is to be concentrated to a 50 per cent caustic solution; at the intersection of the ordinate 40 and the abscissa 50 we find that the heat of dilution or vice versa, the "heat of concentration," is 210 B.t.u., for every pound of water so evaporated. Thus, in the heat-balance equation for one evaporator effect there might be an equation like this, where x is the weight of water evaporated in that effect:

$$(1865 - x)\ (161) + 1104x + (5439)\ (181) + 210x = (1865)\ (203) + (4259)\ (224) + 1150x$$

It will be seen that after solving this equation for its unknown, the actual amount of "heat of concentration" required may be calculated.

Now, in order that we may see the effects of heat of chemical combination and rise in boiling-temperature combined, let us examine Chart 16. The forward-flow operation is an impossible case as far as practice is concerned, on account of the high pressures we have to contend with. This chart shows the conditions encountered in evaporating an 8.54 per cent caustic soda solution at an original temperature of 160 deg. Fahr., to a 50 per cent solution. It will be seen that in effect No. 2 backward-flow operation, the liberation of steam is greater than in effect No. 1. Heretofore we have had no such abrupt changes. Let us see how this happens. In effect No. 1 there is a high heat of chemical combination, all of which heat is furnished by the latent heat of the live steam, and consequently the steam liberated will be very much less than it would be if there were only a low heat of chemical combination. In the second effect, however, there is a large quantity of condensed steam from the first, cooling approximately 93 deg. This liberates heat enough to raise the evaporation of steam in that effect above the abnormally low value of the first effect. Referring to Chart 15, it will be seen that the heat of combination between 26.1 per cent and 50 per cent concentration is 109 B.t.u. per pound of water evaporated. This same condition applies to forward-flow, but is not so noticeable (see Effect 5), first, because of the large increase in evaporation from effect to effect; second, because the concentration is in that case between the values 21.6 per cent and 50 per cent, instead of between 26.1 per cent and 50 per cent. If, however, the differences are subtracted and the results compared with the preceding charts, the effect of this property will be apparent.

In Chart 11 it was demonstrated that the forward-flow method was more economical of steam when the liquor to be evaporated had been preheated to a considerable extent, viz., 160 deg., in this illustration. But it does not follow that because this is true of liquids in which concentration does not materially raise the boiling point that it is true for those liquids which increase markedly in boiling point on concentration. Thus, Chart 16 shows that backward-flow evaporation is decidedly more economical in steam than the forward method for caustic soda. Here it will be seen that the loss of heat in the drip, due to its high temperature, more than offsets the extra heat lost through the condenser in backward-flow.

Chart 17 is submitted showing the evaporation of the same caustic soda liquor with the conditions the same except that the liquor enters at 32 deg. Here the same rise in evaporation in No. 2 effect backward-flow is

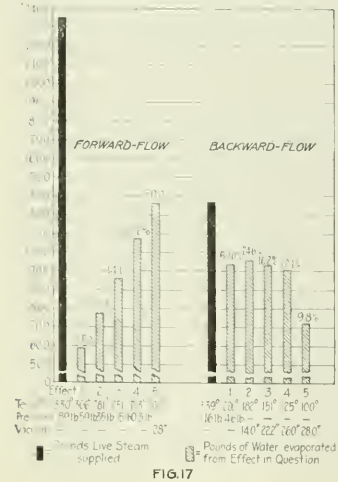

FIG. 17

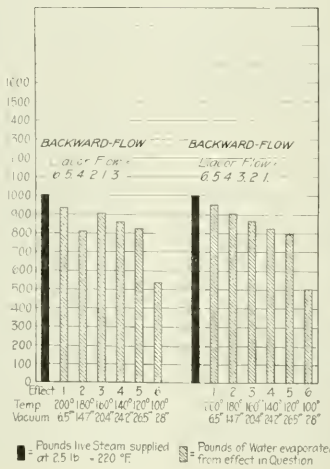
BACKWARD-FLOW
BACKWARD-FLOW
Liquor Flow
6 5 4 2 1 3
6 5 4 3 2 1
Effect 1 2 3 4 5 6
Temp 200° 180° 160° 140° 120° 100°
Vacuum 6.5° 14.7° 20.4° 24.2° 26.5° 28°
Pounds Live Steam supplied at 2.5 lb = 220 °F.
Pounds of Water evaporated from effect in Question

FIG. 18

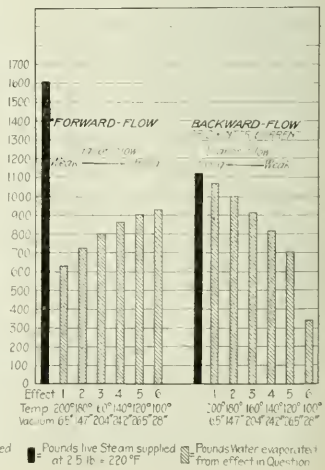
FORWARD-FLOW
BACKWARD-FLOW
Effect 1 2 3 4 5 6
Temp 200° 180° 160° 140° 120° 100°
Vacuum 6.5° 14.7° 20.4° 24.2° 26.5° 28°
Pounds Live Steam supplied at 2.5 lb = 220 °F
Pounds Water evaporated from effect in Question

FIG. 19

apparent, and the decrease in evaporation of No. 5 effect in forward evaporation is equally apparent; as before, the abnormalities are due to the large heat of chemical combination at these points.

In the two last charts the effect of the heat of chemical combination has been illustrated, using a caustic soda solution as an example. In this case the heats of chemical combination are positive. It might be interesting to take an example such as the concentration of ammonium nitrate, in which the heats of dilution with water are negative. The time at the writer's disposal does not permit of his making the necessary charts or calculations, however, and, moreover, we have already considered the subject of heat of chemical combination as fully as it justifiable in a general paper.

Usefulness of the Charts

A study of the charts already submitted will show that not only do they give an idea of the consumption of steam and the mechanical strength required, but that by calculating a chart for the problem in hand one can save in first cost of equipment. For instance, in Chart 16, the condenser for backward-flow operation could not be much smaller than in forward-flow, though the boiler might be smaller. This chart also shows that the piping into the condenser in each case would be nearer the same size. Also, inasmuch as the amount of steam to be condensed is very nearly the same, the amount of water to be handled is much the same.

Comparing the two divisions of Chart 17, one will see that the boiler has to be approximately 70 per cent larger for forward evaporation than for backward evaporation. The condenser in the former has to possess 90 per cent greater capacity than in the latter, and the water supply and equipment must also be greater. The question of water supply alone might decide one in favor of the backward-flow type of evaporation.

Another fact to be observed is that in the backward-flow process the intermediate piping can, as a rule, be approximately of uniform size without waste, while such is not true of the forward-flow method. The former method lends itself better to standardization.

A further study of the subject will show that in the forward-flow method, to a much greater degree than in the backward-flow method, adding an additional effect does not give a proportionate economy of evaporation, and that interest on the investment and maintenance charges may more than offset the economy gained.

Temperature Difference of Exchange

In the foregoing illustrations the temperature difference of 20 deg. Fahr. has been used in each instance. This has been done in order that the point which we wish to consider shall not be obscured by greater variations. It is not, however, meant to intimate that evaporation is always done under 20 deg. difference of exchange, or that 20 deg. is preferable to 10 deg. or 25 deg. The writer is familiar with an evaporator in which the following are the approximate differences of exchange: 8 deg., 9 deg., 15 deg., 20 deg., 26 deg. and 70 deg. This is due to the increase in viscosity of the liquor.

Where a liquor tends to decompose or "gum up" on concentration at high temperatures, and becomes viscous at low temperatures, there is still another procedure which can be followed. Suppose the travel of the liquor is as follows, the effects being numbered serially: 6, 5, 4, 2, 1, 3. Here the liquor gives up its last water at a temperature high enough so that it will remain mobile. A large number of these combinations might be made, and the subject is of enough importance to warrant investigations along this line. The experimental data available at present is not sufficient to warrant submitting many calculations. We have, however, gone far enough in certain experiments to lead us to believe that in spite of the extra complications this method will be useful under certain unusual conditions.

Chart 18 shows that in comparison liquor evaporated backward in the order 6, 5, 4, 3, 2, 1 and backward in the order 6, 5, 4, 2, 1, 3, all the other conditions are alike. It will be seen that the steam consumption is the same in each case, but this is only a coincidence and would vary if the order was changed, the difference of exchange, etc., etc. The coincidence in this case is brought about by recovering some of the heat of the liquor at high temperature from No. 1, which increases the evaporation in 3, 4, 5 and 6, thereby making up for the loss of the decreased evaporation in 1 and 2. It is interesting to note the high evaporation in No. 3, which is due to not having to raise the entering liquor 20 deg., and also due to the giving up of steam by the liquor from No. 1 as in forward evaporation.

If liquor is to be sprayed into a furnace to be evaporated by radiant heat, as described in a previous paper by the author, this backward method, viz., 6, 5, 4, 2, 1, 3, has decided advantages, as the liquor goes in at 160 deg. F. instead of 100 deg. F.

As the thermal coefficient increases with the velocity of the liquor (and therefore also with its mobility) it will be readily seen that by increasing the velocity (or mobility) the heating surface required can be reduced.

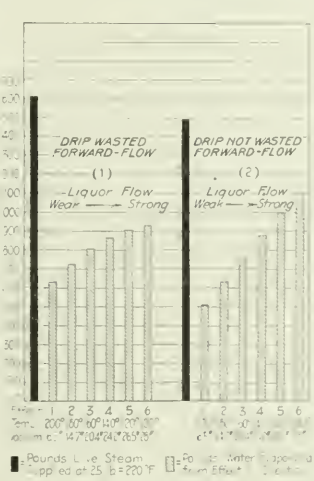

FIG. 20

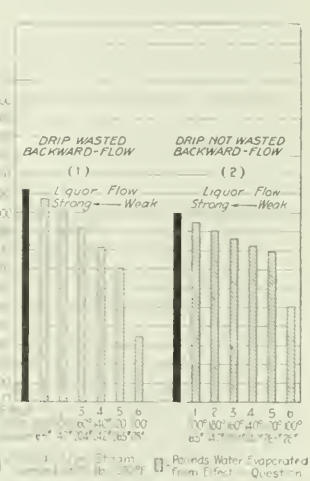

FIG. 21

The velocity or mobility of the liquor is not, however, the only thing to be considered in designing the heating surface of multiple effect evaporators. If air accumulates in the steam space, the effect is the same as reducing the heating surface. It has been assumed for lack of better knowledge on the subject that this effect is in direct proportion to the per cent by volume of air present and the evaporator designer will not go very far wrong if he goes by this rule. The accumulations of air in only one effect may stop the operation of every evaporator in a multiple-effect system. It will thus be seen that evaporators should be so designed that the inlet and outlet for air and its accompanying steam will be so located as to prevent air pockets.

Drip from Evaporators

Many manufacturers waste the condensed steam, that is, they remove the "drip" of each effect separately, and do not try to obtain the available heat therein. This in some cases is justified, though as a general practice the principle is unsound. A justifiable use is in the case of foamy materials where the liquor may be expected to foam over without warning. In this case, if the drips are kept separate, only a portion of the drip liquor would have to be re-evaporated in case of accident, instead of the whole. The efficiency, however, is not as great as when the drip is carried from one effect to another. If the saving due to less re-evaporation is greater than the saving in steam, the method is justifiable. Chart 19 shows the effect on the steam consumption in both forward and backward evaporation by wasting the drip from each effect.

The comparison is more striking if we compare the forward flow with forward flow in Chart 10, and backward flow with backward flow in Chart 10.

Charts 20 and 21 show this comparison, and in the case given for forward evaporation requires 5.6 per cent more steam, and for backward evaporation 12.2 per cent more steam. It is also interesting to note how the wasting of the drip changes the relative evaporations from effect to effect.

This paper does not pretend to go into the matter of steam consumption, the utilization of waste heat in steam to condenser, in drip and hot liquor. Much of this heat can be profitably saved, but as this is not a paper on heat utilization, but on evaporation, this phase will be passed over.

Multiple-effect evaporators should be connected with by-pass valves, so that any effect may be repaired while the others are running.

In conclusion, the writer wishes to express his hope that this paper may suggest subjects for a full discussion, by which means he is sure matters of the greatest interest and profit to the Society may be brought out. He also wishes to acknowledge valued assistance rendered by Mr. W. B. Van Arsdel in the preparation of the material presented.

Brown Co.
Berlin, N. H.

No Spring Meeting for American Chemical Society.—The directors have voted to omit the Spring meeting of the society, which was to have been held in St. Louis the coming April. It was felt that the transportation conditions are such that unnecessary travel should be avoided, and also that the chemists of the country are too busily engaged in meeting war needs.

The Physical Properties of Copper and the Factors by Which They Are Affected*—II

By Paul D. Merica
Division of Metallurgy, U. S. Bureau of Standards

(*Continued from page* 127)

4. Mechanical Properties

In any discussion of the mechanical properties of any material, it must constantly be borne in mind that most of the characteristics determined are more or less dependent upon the method of their determination; the size and shape of test-piece used, the rate of loading, etc., as well as upon the previous mechanical and heat treatment of the material. This is much less true of the elastic properties, the moduli, etc. In general, therefore, it is not possible to assign definite values to these mechanical characteristics; only the range of values given by pure material treated in different ways can be given.

Martens, in an article of great value to those interested in the testing of copper (140), has shown that in the case of copper a variation of testing speed amounting to from 0.5 per cent to 40 per cent elongation per minute causes a difference in the value of the ultimate tensile strength of less than 2 per cent.

Ludwik (139) has, however, shown that for longer periods, the effect of time in testing is quite large. He found that a ½-mm. diameter electrolytic copper wire which sustained a load of 4958 grams for 5 minutes sustained a load of only 4500 grams for 90 hours and one of 3950 grams for 1¼ years.

Martens also showed that although the form of the test piece—ratio of test length to cross section, distance of test length from shoulder of test specimen, etc.—had practically no effect on the values of the ultimate strength and yield point of copper, it exerted a marked effect on the elongation and reduction of area in the tensile test; variations of 15 to 30 per cent were obtained on the same material by varying the ratio

$$\frac{\text{length}}{\text{cross section}} \text{ from } 1/20 \text{ to } \tfrac{1}{2}.$$

(*a*) *Elasticity.*—There is some divergence among the results of determinations of Young's modulus for copper. Values of from 12,100 to 12,300 kg./mm.^{2} (17.2 to 17.5 $\times$ 10^6 lb./sq. in.) have been obtained by careful investigators for electrolytic copper. Determinations by Searle (121) showed a value of 17.6 $\times$ 10^6 lb./sq. in. for drawn and of 18.3 $\times$ 10^6 lb./sq. in. for annealed copper. The temperature coefficient of E at ordinary temperature for copper is given by Wassmuth (125) as $\alpha = 3.59 \times 10^{-4}[E = F(1 + \alpha t)]$ and is negative, *i.e.*, the modulus decreases with rise of temperature. Some values for the moduli at different temperatures are given in Table II.

Poisson's ratio for copper is 0.33 ± 0.01; its temperature coefficient (0 deg. to 150 deg. C.) about 0.00023.

The modulus of torsion for copper as given by Koch and Dannecker (124) is 4240 kg./mm.^{2} (6.15 $\times$ 10^6 lb./sq. in.).

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*Extract from forthcoming Bureau of Standards' circular on copper.

TABLE II—INFLUENCE OF TEMPERATURE ON THE ELASTIC MODULI OF COPPER

Temperature, (°C	Mean Modulus of Torsion, Lbs./ Sq. In. (124)	Young's Modulus[1], Lbs. Sq. In. (144)	Young's Modulus[2], Lbs./Sq. In. (144)
0	.....	.....	.....
20	6.02×10^6	17.8×10^6	18.1×10^6
100	5.82×10^6	.....	18.1×10^6
150	.....	.....	.....
200	5.58×10^6	14.3×10^6	15.6×10^6
250	.....	.....	.....
300	4.85×10^6	11.8×10^6	13.5×10^6
350	.....	.....	.....
400	.....	10.1×10^6	.....
500	3.96×10^6	.....	.....
600	.....	.....	.....
800	2.72×10^6	.....	.....
1000	2.10×10^6	.....	.....

[1], [2] determinations on different samples of copper

The modulus of hydrostatic compression for copper is approximately 12,000 kg./mm.² (20).

(*b*) *Tension test.*—Pure copper may be best normalized by casting, rolling and drawing, followed by annealing for one-half to one hour at about 500 deg. C. and then by slow or quick cooling; after this treatment there is less variation between different samples in the results of the tensile test than in any other condition. The tensile characteristics of copper in this state may be summarized as follows:

Ultimate tensile strength, 35,000 ± 5000 lb./sq.in.
Elastic or proportional limit not determinable.
Elongation in 2 in., 40 to 60 per cent.
Reduction of area, 40 to 60 per cent.

It will be noted that no value is given for the elastic or proportional limits; the usual method of determination of these quantities does not yield any value; *i. e.*, annealed copper yields slightly with the slightest loads which are applied in testing. The values of the moduli given above are determined generally on hot rolled material in which a practical proportionality exists for very small loads.

When copper is cold-worked, rolled or drawn, the

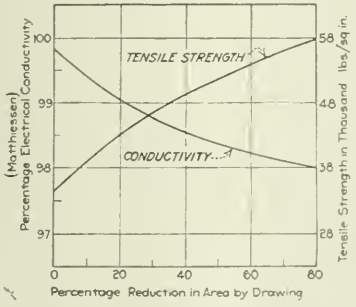


FIG. 15. EFFECT OF COLD WORK ON ULTIMATE TENSILE STRENGTH AND ELECTRICAL CONDUCTIVITY OF PURE COPPER (ADDICKS, 184)

The ultimate tensile strength and the per cent electrical conductivity are plotted as a function of the per cent reduction (area). The wires tested were drawn to No. 12 B. & S. gage from different sizes of annealed copper rod

hardness and ductility are increased and decreased respectively; at the same time a limit of proportionality makes its appearance. The hardness and ductility of such material depends on the amount of cold work or reduction (rolling or drawing) it has received. Figs. 15 and 16 give a good idea of the changes in these quantities in copper strips with various degrees of cold reduction.

Experiments made at this bureau have shown that modern hard-drawn copper wire is equally affected by drawing throughout the section, and that no hard or exterior skin exists. This has been corroborated by Peirce (141).

A good indication of what tensile test values are to be expected in commercial copper wire, hard, medium,

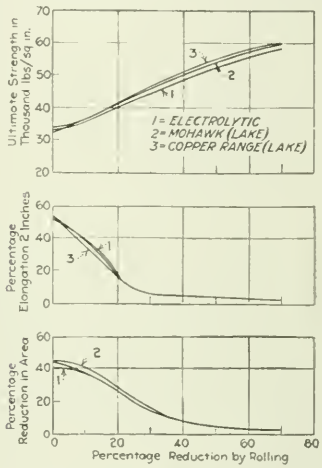


FIG. 16. THE EFFECT OF COLD WORK ON THE MECHANICAL PROPERTIES OF COPPER (TENSILE TEST). (MATTHEWSON & THALHEIMER, 191)

There are plotted the ultimate tensile strength, the elongation in 2-in. and the reduction of area for copper strips rolled to different gages from an annealed strip 0.128 in. in thickness as functions of the percentage reduction of area.

	Per Cent Oxygen	Per Cent Arsenic	Per Cent Silver
Curve 1. Electrolytic copper.....	.071	.000	.0005
Curve 2. Mohawk copper (Lake)....	.052	.096	.069
Curve 3. Copper Range copper (Lake arsenical	.055	.296	.052

drawn and soft may be obtained from the American Society for Testing Materials Specifications.

By increasing the current density and employing a rapidly rotating cathode, Bennet (133) has been able to produce electro-deposited copper of a hardness approaching that of hard-drawn copper; *i. e.*, of a tensile strength of 68,000 lb./sq. in. Some experiments indicating the effect of varying current density upon the mechanical properties of copper were earlier obtained by Von Hüble (137).

Thurston (147) and others give values of the results of the tensile test on copper in different conditions.

TENSILE TEST

Material	Ultimate Strength, Lb./Sq. In.
Cast copper	22–36,000
Copper, forged	34,000
Copper, bolt	36,000
Copper, sheet	36,000
Copper, wire	62,000

(*c*) *Compression Test.*—Copper of good quality does not fail in the compression test by fracture, it merely yields indefinitely and becomes flattened out.

Thurston (147) states that the resistance of copper

to compression may be calculated (within the limits $e < \frac{1}{2}$) from the formula

$$c = 145{,}000 \sqrt[3]{e}$$

c = resistance in lb./sq. in. of original area

e = fractional compression

This formula holds, according to him, for compressions up to 50 per cent for cylinders of three diameters' length.

(*d*) *Torsion Test.*—Thurston (147) states that copper shafts will break under load when

$$d' = \sqrt[3]{\frac{Fl}{4000}} \text{ or } d' = \sqrt[3]{\frac{Fl}{8000}}$$

according as they are of cast or worked copper.

d' = diameter in inches

F = torsional moment

l = lever arm

He also gives the equation

$$d' = \sqrt[3]{\frac{5.1\,Fl}{S'}}$$

where S' for copper should be from 15,000 to 30,000 lb.

(*e*) *Shear Test.*—The shearing stresses for copper are given in the *Ordnance Manual* of the United States War Department. The shearing resistance of copper may be taken (Thurston, 147) as equal to that of the ultimate strength in tension and subject to the same variations; *i. e.*, in the annealed or cast condition, 22,000 to 36,000 lb./sq. in. The work done in shearing copper (for punched holes) is (147)

$W = 96{,}000\,dt$

W = work in foot pounds

d = diameter of hole

t = thickness of plate or sheet

(*f*) *Transverse Bending Test.*—Thurston (147) gives the modulus of rupture as varying between 20,000 and 40,000 lb./sq. in.

(*g*) *Hardness Test.*—It is well known that this property is expressed in many different ways, many of them quite arbitrary.

On the Mohs or mineralogic scale copper has a hardness of from 2.5 to 3. Tammann (146) states that soft and hard copper gave the same values of sclerometer hardness. A hardened steel needle (Martens sclerometer) gave a scratch of 0.014 to 0.016 mm. width when loaded with 10 grams, and one of 0.022 to 0.027 mm. when loaded with 17 grams.

The scleroscope hardness of annealed copper varies from 6 to 7 (universal hammer), whereas that of hard copper (cold reduction of 66 per cent) varies from 22 to 24 (186).

The Brinell hardness of annealed or cast copper is 35 ± 5 (500-kg. load, 10-mm. ball); when hardened by cold work the ball hardness thus defined may become as high as 100. Guillet (189) has determined the ball hardness and the tensile strength of copper in various states of hardness, produced by pressing annealed copper in a steel die to different thicknesses. His results are given in Table III.

Table III—Brinell Hardness of Copper

Per Cent Cold Reduction of Section	Brinell Hardness Numeral, 500 Kg.		Tensile Strength, Lb./Sq. In.	Elongation in 11 Cm. per Cent.
	10 Mm. Ball	5 Mm. Ball		
Annealed 0.....	42	50	33 600	46
10.....	70	74	36 000	24
20.....	81	81	40 000	13
30.....	86	90	45 000	5
40.....	94	92	47 800	4.5
50.....	96	95	52 600	4.2

It is seen that that ratio of $\frac{\text{tensile strength}}{\text{Brinell hardness}}$ is variable with the hardness of the copper.

(*h*) *Impact Test.*—Impact tests of copper have been so few that no final or typical values could be chosen from the data. Baucke (132) has carried out a number of tests according to Frémont, using rectangular bars 10 x 10 mm., with a sharp saw-notch of 3 mm. depth; the specific impact work was measured. Some of the results are given in Table IV. He compares the tensile strength, reduction of area and elongation (in (?) in.). For certain special brands carrying arsenic, nickel and iron (98.5 to 99.9 per cent copper), giving tensile strengths of from 20 to 31 kg./mm.^{2} (28,400 to 44,000 lb. / sq. in.), elongations of from 40 to 50 per cent, reductions of area of from 50 to 77 per cent, the specific impact work varied from 10 to 33 kg. M. (72.4 to 239 ft. lb.) in longitudinally cut specimens and from 9 to 31 in transverse specimens. For ordinary brands, oxygen content 0.11 to 0.06 per cent, copper 99.5 to 99.8 per cent, having tensile strengths of from 21 to 24 kg. mm.^{2} (30,000 to 34,000 lb. / sq. in.), elongations of from 30 to 47 per cent, reductions of area from 33 to 70 per cent, the specific impact work varied from 10 to 15 kgM. (72.4 to 109 ft. lb.) in longitudinally cut specimens and from 3 to 11 kgM. (21.6 to 79.5 ft. lb.) in transverse specimens.

Table IV—Impact Tests of Copper. Baucke (132).

Chemical Composition.

Impurities in 0.01 per Cent										Specific Impact Work. (1)	
Antimony	Tin	Arsenic	Lead	Bismuth	Iron	Zinc	Nickel	Manganese	Oxygen	Per Cent Copper	Kg. M.
Commercial fire-box plates										L	T
..	3	33	2	<1	11	1	..	..	6	99.44	11.0	10.5
..	..	..	1	..	2	..	9	..	8	99.80	11.0	5.5
..	..	..	11	..	4	12	..	..	8	99.57	9.0	6.1
..	..	1	3	1	5	..	23	..	10	99.57	10.9	3.1
..	2	..	5	1	3	22	10	..	10	99.48	10.8	9.1
..	1	..	..	<1	2	..	1	..	11	99.81	10.4	5.3
..	..	1	6	..	5	9	22	..	11	99.47	10.5	....
1	..	..	35	1	1	..	2	..	11	99.30	8.3	5.3
..	..	..	2	<1	19	1	..	..	11	99.66	13.6	10.1
..	1	..	3	<1	2	..	1	1	11	99.81	19.0	6.6
..	..	14	7		4	14	..		12	99.50	8.3	5.3
Special copper (Heckmann) for plates											
	201					45				28.6	26
	82	..	..	..	..	40	..	..	..	28	
	..	7	..	..	3		4	..	..	18	

(1)—Baucke gives S. I. W. in kilos, but it is assumed that he means kilogram-meters.
L = longitudinally-taken specimens.
T = transversely-taken specimens.

5. Miscellaneous

(*a*) *Density.*—The density of pure copper, rolled, forged or drawn and afterward annealed, may be taken as 8.89 at 20 deg. C. This value was accepted by the

International Electrotechnical Commission in 1913. Samples of high conductivity copper will vary (149) usually between 8.87 and 8.91; in some cases samples have shown densities as high at 8.94 and as low as 8.83. Variations in density may be due to microscopic flaws or seams (low density) or to the variation in the percentage of oxygen present (0.03 per cent oxygen lowers the density by about 0.01). The density of cast copper will be about 8.89 when no blowholes are present; otherwise lower densities will be found.

According to experiments by G. L. Heath (148) there is but an extremely small difference between the density of hard-drawn and hard-drawn annealed copper. No difference in density is detected between the two high grades of copper. The mean density of 10 hard-drawn samples of wire was 8.898; after these samples had been annealed their mean density was 8.900, showing an increase of density upon annealing of approximately 0.02 per cent. Similar values of the increase in density of hard copper upon annealing have been found also by Gewecke (187) and by Kahlbaum-Sturm (150); these ranged from 0.001 to 0.10 per cent, and averaged about 0.02 per cent.

(To be Continued)

Intensive Toluol Production—II.

Proposed Improvements in the Concentrating and Refining Process

By Frank E. Lichtenthaeler

CRUDE light oil containing benzol, toluol and other less important constituents is obtained by subjecting the vapor-gas mixtures of these substances to the absorbing action of a higher boiling medium, with subsequent heat treatment of the absorbing medium to remove the recovered volatile portion. This is commonly known as the absorbing and stripping process for toluol recovery. In a previous article[1] dealing with this process we have recommended the use of tar as the most suitable absorbing medium, at the same time offering improved procedure and plant, broadly conceived, in the hope of contributing toward a quick and permanent relief of the existing critical situation in respect to the deplorably short supply of toluol.

Present Concentrating and Refining Process

The usually accepted method of working up the crude light oil to produce "toluol pure" has been described at length in other publications, of which the recent and interesting report of the United States Bureau of Standards is mentioned in the way of reference. The crude light oil is roughly separated by distillation into three fractions, known as crude benzol, crude toluol and crude solvent naphtha, by means of a periodic still having a short rectifying column. The crude toluol fraction is treated chemically with sulphuric acid to remove olefines and other unsaturated bodies, washed with water, neutralized with dilute alkali solution and again washed with water to remove any excess of alkali. The olefine-free toluol fraction is finally distilled in a periodic rectifying still, using a tall column of standard bell-and-seal type with external reflux condenser or dephlegmator. In the latter operation the finished toluol-pure fraction constitutes the middle portion or heart of the run. These related operations, or their equivalent, we have termed the concentrating and refining process.

Evolution of Present Procedure

In the hope of developing a better perspective in regard to the toluol concentrating and refining process, it seems desirable to review briefly the evolution of the above mentioned procedure. Contrary to the older and more highly developed European chemical practice, there has been a marked tendency in America to employ inadequate apparatus for carrying out the initial steps of a process, without realizing that the imperfect result, directly attributable thereto, predetermines the necessity of more elaborate and difficult refining operations at the end. Our synthetic chemical industry is replete with striking illustrations of this fallacious practice, although there are exceptions pointing to real progress due to more logical conceptions and a willingness to make judicious expenditures for well adapted plant for preliminary work in order to simplify succeeding operations.

Naturally, the development of light-oil concentrating and refining has followed a similar channel. Formerly the crude light oil was distilled and redistilled in plain stills, without columns or dephlegmators, and extremely rough concentrations were thus effected. Consequently the tax on the chemical washing operation was heavy and the shrinkage at this point considerable. The rectifying operation was carried out in antiquated types of column stills, the supposed advantage being that they were cheap to build. Two or three distillations were thus required, the excessive and accumulative cost of which long escaped attention. In course of time it occurred to some venturesome innovator to try a fractionating column in connection with the initial distilling operation. The column, if we may dignify it as such, consisted of an upright piece of pipe filled with coke or quartz pebbles. A decided improvement resulted, and all those divining the secret immediately did exactly likewise and profited accordingly. Another lapse of time and the idea suggested by the pebble column again overcame inertia, with the result that the present short cap column and dephlegmator were applied, notwithstanding the radical departure this step involved. The results were surprisingly good, which brings the history to date where progress once more pauses to further demonstrate the fallacy of leaving well enough alone.

Analogous Development of Wood Chemical Practice

The development of the wood chemical industry in America affords an interesting analogy to the above. Crude methods and apparatus have been adhered to with astonishing tenacity worthy of a better cause. Consider for example our time-honored practice of producing 82 per cent crude wood alcohol, yellow with tar, loaded with the most baffling impurities, and requiring elaborate and repeated treatments by distillation and chemicals to eventually yield a semi-refined alcohol. The magic of 82 per cent crude rests solely in the fact that this was the highest concentration attainable with the old-fashioned Burcey pan stills even now in use at some of the plants. This has set the pace for present and future generations, with here and there an isolated exception, notwithstanding the fact that our Canadian neighbors have long since discovered that by continuous concentration of the neutralized wood liquor

[1] This journal, Feb. 1, 1918, pp. 144-152.

in an efficient column still of modern design the tar and oily impurities can be eliminated completely at the start, distilling over a water-white highly concentrated product, which may be sold directly as wood alcohol or very easily refined to pure methyl alcohol 99½ per cent strong containing below one-eighth of 1 per cent of acetone.

This nearly parallel case is referred to as suggesting the desirability of applying to the concentrating and refining of crude light oils certain definite improvements in distillation methods and apparatus which have contributed so much toward better economy in the wood chemical field. A comprehensive system of concentrating and refining volatile liquids by distillation has been developed, based on our experience and observations extending over many years; a system that has been thoroughly and successfully tried out not only in the wood chemical field, but in various other instances, always involving a crude material of complicated composition from which it is desired to isolate one or more volatile components in a highly refined condition. This system has, as its foundation, the premise that the concentrating operation, *i. e.*, the isolation of fractions in which the desired components predominate, by the very character of the work to be performed, demands apparatus of the highest practical efficiency. Thus only can objectionable impurities be removed that otherwise persist as an unnecessary burden through all succeeding operations. Needless labor and operating expense thus eliminated at the start represent a very substantial economy, as compared to the more usual practice, especially in the case where valuable materials are to be handled on an enormous scale. Could there be a more opportune occasion for the application of this obviously more logical and economical procedure than presented by the unsatisfied demands for an unlimited supply of toluol for war and after-war needs?

Other important benefits to be derived from the use of efficient concentrating stills for the preliminary fractionation of crude light oil may be enumerated. Olefines are more completely removed from the principal concentrate, crude toluol, so that the latter requires correspondingly less sulphuric acid in the chemical treatment. Furthermore, these otherwise lost olefines, together with separable paraffines, become readily available for gas enrichment. High concentration obtainable in respect to toluol means less benzol and solvent naphtha to be removed in the final rectifying operation, with consequent higher yield of toluol in one operation. It directly follows that the final rectifying still, having less work to perform, may be correspondingly smaller. The reduced steam consumption alone, due to economies made possible by continuous operation, affords ample justification of the suggested procedure.

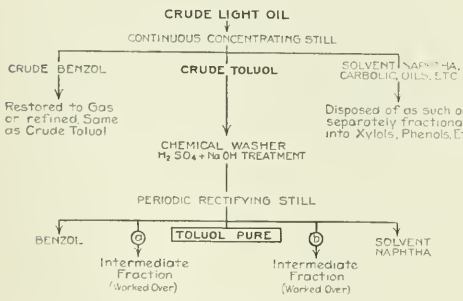


FIG. 7. LUMMUS SYSTEM OF "LIGHT OIL" CONCENTRATING AND REFINING

Light-Oil Concentrating and Refining

The Lummus system of light-oil concentrating and refining, as illustrated diagrammatically in Fig. 7, is described briefly as follows:

The crude light oil is handled directly in an efficient continuous concentrating still, which effects a simultaneous separation into three concentrates, which we will term crude benzol, crude toluol and solvent naphtha. The crude toluol fraction, containing all the toluol present in the original light oil, together with a small percentage of lower and higher boiling impurities, is next treated chemically with sulphuric acid to remove olefines and other unsaturated bodies, washed with water to remove acid left in suspension, then with dilute caustic soda solution to neutralize the remaining traces of acid, and finally again washed with water to remove any excess of caustic soda. The neutral crude toluol is then fractionated in an efficient periodic rectifying still, the following fractions being collected in order of their increasing boiling points: benzol, intermediate fraction *a*, toluol-pure, intermediate fraction *b* and solvent naphtha. Toluol-pure, forming the main part of the run, is here turned out in finished condition, ready for shipment to the munitions factories, and our main purpose is thus accomplished.

Intermediate fractions *a* and *b*, both containing toluol, are run into the same tank and re-distilled after sufficient quantity has been accumulated for a full still charge, using the same periodic rectifying still mentioned above. The combined benzol fractions, resulting from both the continuous and periodic still operations, may be restored to the illuminating gas, or eventually may be used in the manufacture of explosives. Chemical treatment and final rectifying must be applied to this unfinished material to yield benzol-pure. These operations may be carried out in exactly the same manner as described in connection with crude toluol. The same apparatus may be used for producing benzol-pure provided, of course, that sufficient capacity has been furnished with this end in view.

Assuming that tar has been used as the absorbing medium, as suggested in our previous article, the solvent naphtha fractions referred to above would contain carbolic oils as well as xylols. In this case it may ultimately prove desirable to work up the carbolic oils into phenol for picric acid, thus requiring additional apparatus especially designed for the purpose. As this is a separate undertaking from that of producing toluol, we will not stop at this time to describe in detail the methods and apparatus for working up these side products. The solvent naphtha fractions may be subjected to cracking processes and thus caused to yield additional benzol and toluol in substantial amounts. It was first pointed out by Dr. W. F. Rittman that the mixture of higher boiling aromatic compounds constitutes a highly favorable raw material for producing toluol by cracking either in tubes or furnaces, and as recently confirmed and demonstrated in a timely reminder of

this important possibility, some millions of gallons of toluol could thus be added to the supply.

It will be observed that the concentrating and refining process recommended is practically the same as that commonly followed, except that a continuous concentrating still is employed for the preliminary fractionation in place of the short column periodic still usually mentioned. We advocate this radical change

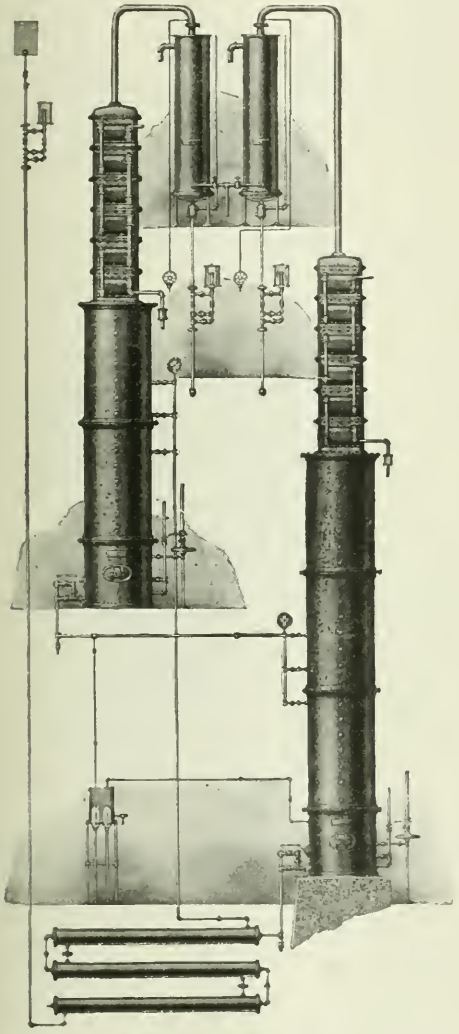


FIG. 8. LUMMUS DOUBLE-COLUMN CONTINUOUS CONCENTRATOR

in order to gain the important advantages referred to in paragraphs six and seven above, none of which is possible with any other type of apparatus. Furthermore, in the final rectifying operation we employ an improved design of fractionating column capable of effecting sharper separations, thus increasing the initial yield of toluol-pure, at the same time materially reducing the quantity of intermediate fractions, which require working over with consequent duplication of expense.

Double Column Continuous Concentrator

The continuous concentrating still, recommended for the preliminary fractionation of the crude light oil, is illustrated in Fig. 8. This is known as the Lummus double-column continuous concentrator, designed for turning out simultaneously the three concentrates mentioned above. This apparatus is of iron construction throughout, and especially adapted to conditions obtaining in the case under consideration. That is to say, while the type of still is one that we have applied broadly to various concentrating problems, the specific apparatus shown is a recent development, designed and proportioned throughout for continuous fractionation of crude light oil into crude benzol, crude toluol and solvent naphtha. Note that both columns include the system of internal refluxing, which, in our opinion, represents the highest development of the art, affording the best means for effecting sharp separations of mixed volatile liquids, with high economy in respect to steam and water consumption. This system will be described more in detail in a later paragraph. Both distilling columns are provided in their bottom chambers with suitable high-pressure steam heating coils and perforated sparger pipes for injecting live steam, although the use of the latter is not always necessary. A heat interchanger is used for economizing the waste heat of the residual solvent naphtha fraction discharged from the bottom of the second column, and ample control of conditions is provided for in the way of column pressure regulators, recording thermometers for charting the boiling points of distillates, dial thermometers for the various feed liquors, feed and product gages for measuring the rate of flow of both feed and distillates, also special testers for checking the liquor discharged from the first into the second column and for indicating the composition of the residual solvent naphtha fraction.

Referring to Fig. 8, the crude light oil flows by gravity into a small constant-head float tank from a suitable elevated storage tank. The rate of flow of the crude light oil, fed continuously to the apparatus, is controlled by a suitable valve and accurately measured by a feed gage, as shown at upper left-hand corner. The crude light oil next is heated in heat interchanger, shown at bottom of cut, by means of the waste heat of the solvent naphtha fraction and is then admitted to column No. 1 through one of the manifolded inlet connections. The temperature of the inflowing feed is indicated by a dial thermometer. The conditions in column No. 1 in respect to the amount of heat supplied and the temperature maintained throughout the internal reflux system are adjusted to cause the vaporization and concentration of the so-called crude benzol fraction. This fraction, comprising benzol and all lower boiling components—but no toluol—is condensed and cooled in a final condenser from which it flows to its storage tank, the rate of flow and boiling point being indicated by a product gage and recording thermometer shown directly below the condenser.

The residual liquor emerges from the bottom chamber of column No. 1 and crosses over to column No. 2,

[3]Egloff, Jour. Ind. & Eng. Chem., Vol. 10, No. 1.

being admitted through one of the manifolded inlet connections at a fixed temperature indicated by a dial thermometer. In this column conditions in respect to heat and internal refluxing are adjusted to effect vaporization and maximum concentration of the crude toluol fraction, which is condensed and cooled in its respective final condenser from which it in turn flows to its storage tank, the rate of flow and boiling point also being indicated by a product gage and recording thermometer, as shown. The crude toluol fraction comprises all of the toluol present in the original crude light oil, together with small percentages of benzol, olefines, paraffins and traces of other components boiling slightly higher than toluol.

The residual liquor, known as solvent naphtha, and comprising components of higher boiling point than toluol, flows from the bottom chamber of the second column through the heat interchanger previously referred to and thence to its storage tank. It will be noted that the three products are turned out simultaneously and at a continuous uniform rate throughout 24 hours of the day. There is no time lost for still charging and dumping, nor for heating and cooling the charge—these being the inherent disadvantages of the present periodic or batch concentrating stills.

Internal Reflux System

A brief description of the Lummus internal reflux system may not be out of place at this point of our discussion, together with a statement of our reasons for applying this system to the concentration of crude light oil fractions. All other continuous or periodic column stills employ what is known as an external reflux condenser or dephlegmator, the purpose of which is to flood the column chambers with condensate of reasonably high purity, this being favorable to increasing the purity of the final vapors passing from the top of the column. Unfortunately, by returning this condensate to the top chamber only, this very desirable effect is largely confined to the few uppermost decks of the column with the direct result that an excessive amount of condensate must be returned, which requires a correspondingly excessive amount of steam for re-evaporation, as well as water for condensation. The Lummus patented internal reflux system consists of a number of small reflux condensers or dephlegmators distributed throughout the entire upper part of the column, so that each tray of bells and seals is provided with its individual dephlegmator. By thus distributing the work of refluxing, not only are much sharper fractionations made possible, but this may be accomplished with very much less steam and condenser water. The requisite column construction, although slightly more elaborate than that applying to the externally placed dephlegmator, is eminently practical, and after sixteen years of development has naturally been reduced to routine practice with us, so that the ultimate cost is practically the same as that applying to the somewhat more simple though far less efficient external dephlegmator. The several water-cooled tube bundles, constituting our internal reflux system, are all removable intact for cleaning, testing and replacement of worn out tubes. In fact, this type of apparatus is far more accessible than the less modern external dephlegmator, while so far as operation is concerned, adjustment and control of conditions are accomplished more conveniently and with far greater precision. The water passes in series through all of the internal dephlegmators, so that there is but one water control valve and one overflow requiring attention. The amount of water required by this system for refluxing is frequently as low as one-half that employed by the external reflux condenser, and we have actual tests on record indicating steam consumptions of 35 to 50 per cent of that required by the less efficient apparatus referred to. At the same time, due to the very sharp separations effected, it is possible to greatly reduce the percentage of higher and lower boiling impurities in the main concentrate, namely, crude toluol, thus materially lessening the difficulty and cost of the subsequent refining operations. Other impurities which, due to proximity of boiling points, are generally regarded as inseparable, may sometimes be eliminated by this type of still head.

Chemical Treating Process

Proceeding next to the subject of chemical treatment, it seems that this must remain, for the present at least, a rather clumsy makeshift, obtruding itself in the midst of an otherwise fairly well ordered process. For sheer

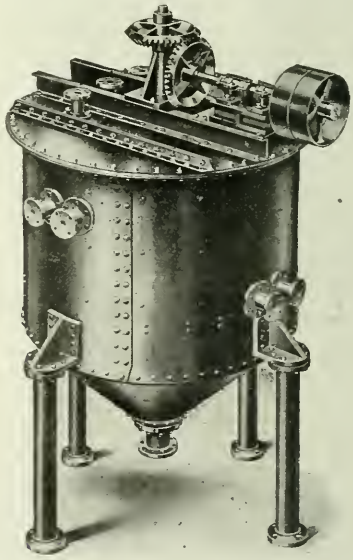


FIG. 9. CHEMICAL WASHER

lack of a worthy substitute, it becomes necessary to adhere to the established procedure involving the treatment of large batches of crude toluol with small doses of chemicals, imitating on a large scale the laborious separatory-funnel laboratory method of adding, shaking, settling, drawing off, and so on, repeatedly. Olefines and similar unsaturated compounds, because of proximity of boiling points or due possibly to the formation of constant boiling-point mixtures, have not been separated from toluol by distillation alone. Therefore sulphuric acid is employed to form water-soluble sulphonates which then may be removed by settling and separation of the acid layer, followed by neutralization with alkali together with thorough washings with

water. These operations are carried out in the so-called washer, illustrated in Fig. 9. The washers are lead-lined for the sulphuric acid treatment and of plain steel construction for the alkaline treatment. They are closed tight, with removable cover sections to minimize evaporation losses, and provided with high-speed screw agitators and cylinders to cause thorough mixing. The acid washer has lead cooling coils suspended just below the liquor level to remove the heat generated by the

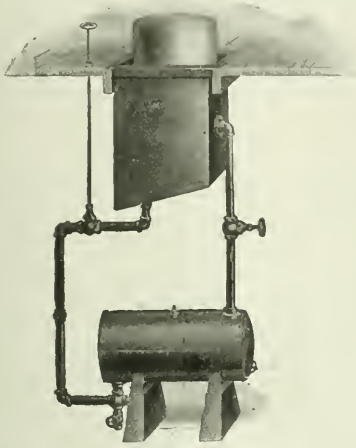


FIG. 10A. ONE-DRUM PATENT AUTOMATIC DISSOLVER

acid reaction. The balance of equipment for the chemical treatment consists of a lead-lined tank for acid storage and a plain steel tank for caustic soda solution.

The handling and dissolving of caustic soda is always a disagreeable and even dangerous operation. Actual first-hand experience with this troublesome material some years ago has since led us to devise dissolving and handling apparatus that seems worthy of mention in the present connection because it so effectually eliminates the usual difficulties. Fig. 10 illustrates two standard sizes of our dissolver as now extensively employed for dissolving whole cakes of caustic soda. Solution is effected rapidly and automatically by the positive circulation caused by the difference in gravity betweel the heavy solution and the much lighter cold water with which the outfit is at first charged. The whole caustic cakes are supported by a heavy cast iron grid in the upper part of the tank; the system is filled with water, so as to partially submerge the cakes, and solution then proceeds to completion without aid of heat or stirring. For very heavy solutions a thermo-syphon is placed in the circulation riser for heating the water to increase its solvency. This, however, is not necessary for producing 30 deg. B. and weaker solutions.

These dissolvers are made in sizes to handle one, two, four, five and ten whole cakes at a time. We also have devised a very convenient form of lifting tongs, capable of gripping the bare caustic cake as it lies horizontally on the floor and permitting the cake, upon lifting, to swing into a vertical position ready for lowering into the dissolver. Thus the entire operation may be carried out in safety without touching or breaking the original cake, with entire saving of steam or power for stirring, and without labor or attendance except as required to charge the dissolver at the start. We have come to consider this simple equipment as forming an essential part of any operation involving the use of considerable quantities of caustic alkali.

Refining Stills

The final rectifying or refining operation is of necessity a periodic or batch process. If a reasonably uniform crude toluol could be produced readily, this depending in turn upon uniformity of composition of the crude light oils, notwithstanding their widely different sources, then it would be feasible to employ a continuous refining still with all the advantages in respect to economy attending continuous operation. If a prediction may be based on parallel development in allied fields, it seems reasonable to look forward to continuous benzol and toluol refining as a highly desirable ultimate aim made possible by eventual standardization of preliminary methods of production with consequent control of light-oil composition. Until this more advanced status materializes, a conservative policy seems to require adherence to the batch refining process. The latter lends itself to a great variety of changing conditions without seriously affecting the ultimate product, toluol-pure. Mistakes made in previous operations can generally be remedied through the medium of a final periodic distillation. The continuous still, on the contrary, is rather inflexible, demanding, especially in the case of a refining operation, fixed conditions which cannot yet be counted upon.

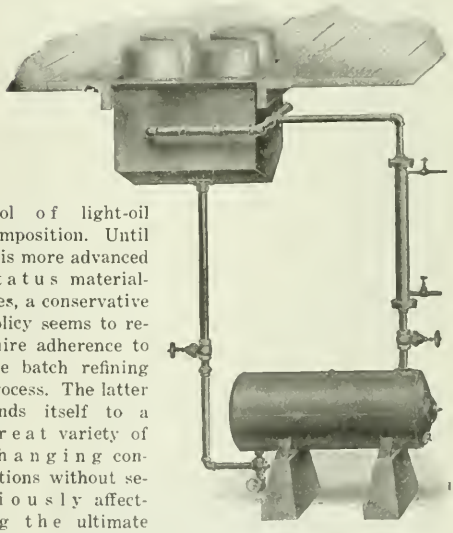


FIG. 10B. FOUR-DRUM PATENT AUTOMATIC DISSOLVER WITH THERMO SYPHON

The type of periodic or batch still usually employed in the toluol refining operation is illustrated in Fig. 11. This apparatus is distinguished by having the familiar external reflux condenser or dephlegmator. The column is of the well known boiling-cap or bell-and-seal type, constructed throughout of cast iron and steel. This standard type of still is furnished by all still manufacturers, our particular make claiming attention only in respect to improved results that may be due to our use of a novel form of slotted vaporizing cap which insures very thorough contact between ascending vapor

and descending liquor within the column, as well as to other minor details of construction which add to the life of the apparatus and the convenience attending its operation.

In this connection it is desired to call attention to an apparently wrong impression that appears to exist in respect to column construction as required for toluol refining. We have noted various detailed descriptions of columns for the purpose, none of which seems to grasp the significant underlying facts which determine the real merit of one type as compared to another. There are, for instance, specific allusions to mysterious column dimensions, such as 3 ft. 3 in. in diameter, with chambers 12 in. to 14 in. in height, conveying the incorrect idea that upon such minor points depend the satisfactory production of toluol. Another article explains that a column for one purpose is required to have serrated caps or bells, and for another purpose the serrations are omitted, but without giving reasons. These statements are mentioned not for their intrinsic importance, which may not be great, but merely as they represent the general tone of the published information in question. Details are always interesting and may be helpful when stated parenthetically for the purpose of illustrating broad discussion. Our criticism refers to the undue emphasis laid upon unessential details and non-representative apparatus types, leading to the inference that classic examples have been set forth, arrived at by a careful exclusion of all but the best. All this may be explained, possibly on the grounds of blind description of accidental apparatus that happened to come within the limited experience of the particular writer. The unfortunate result is that the misleading information, coming from supposedly authoritative sources, inclines the uninformed buyer of apparatus to insist on the absurd and non-essential specifications exactly as published, and the opportunity to educate him to a sane understanding of important determining factors is completely lost. Ignorance, which might have been partly dispelled, has been more firmly grounded by thus setting forth superficialities in the guise of real knowledge.

It must be made clearer to those concerned that column and still details are subject to considerable variation. We have employed column sections as low as 4 in. in height with good results. We regularly make them 6 in., 8 in. or 10 in. high, or higher, as required to obtain a proper balance between desired capacity and economical construction, uninfluenced generally by the particular material to be treated. Serrated caps are always better than plain dipping bells. The horizontally slotted cap, as originated by us, offers certain advantages in respect to release of bubbles at a uniform depth of liquid, more thorough vapor liquor contact and low column back pressure. We hardly could claim that some one's else column would not produce toluol because our patent caps were not used. It should be realized that these differences are mainly of degree, just as one type of gun may offer certain advantages over another, without excluding either type. Would it not, therefore, have been the part of wisdom to leave details of construction to reliable builders of the necessary apparatus, placing emphasis instead upon matters of broader meaning, so that the uninitiated might be helped to a reasonably comprehensive understanding of the tools available for performing the task confronting him. As matters now stand, it will be decided quite naturally that the slightest variation from narrow and rather obsolete specifications, already published, of necessity rejects available equipment which in reality may be far superior to the narrowly defined examples set forth. We are already encountering and endeavoring to combat the retarding effects of this ill-advised yet influential information. If some manufacturer had arranged a campaign solely to favor his particular type of apparatus, the incidental propaganda could not have been more skillfully planned and disseminated. In this case, undoubtedly with the most praiseworthy intentions, the same results are brought about and at a time when intelligent conceptions are badly needed and ill-founded prejudices become serious obstacles in the way of wisely directed co-operative action.

Periodic Toluol Refining Still

Returning to the subject of refining stills, Fig. 12 illustrates the Lummus periodic refining still with patented internal reflux system. We especially recommend this still for toluol refining, in view of its very high fractionating efficiency and economy of operation. It should be plainly understood, however, that the standard apparatus illustrated in Fig. 11 is very well adapted to toluol refining, the difference in

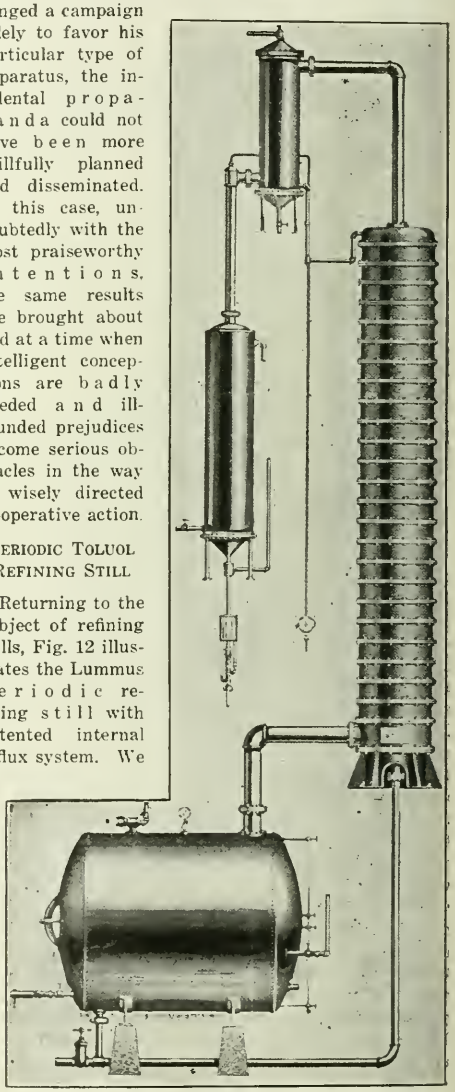


FIG. 11. BENZOL REFINING STILL WITH EXTERNAL REFLUX

favor of the more highly developed apparatus being one of degree only. That is to say, both stills are capable of turning out toluol-pure, but the Lummus type will do so with surprisingly greater economy in respect to steam and water, and the sharper separations permitted result in maximum yield of toluol-pure in one operation with correspondingly small yield of intermediate fractions requiring accumulation and subsequent re-distillation.

The Lummus refining still is constructed throughout of cast iron and steel. The still proper, or boiling kettle, is equipped with high-pressure steam coils arranged in separate groups or bundles to facilitate removal through the specially large manhole for repairs or replacement. The heating surface is arranged in most approved form, that is, a number of comparatively short tubes connected in parallel so as to maintain the velocity of the steam within the tubes and maximum average temperature difference throughout their entire length. There are no threaded joints inside the still. All joints are welded to avoid any possibility of internal steam leaks. The still is also provided with a perforated sparger pipe for injecting live steam, as in some instances preferred for distilling over the higher boiling components. The distilling column, because of its efficient design, may be considerably shorter than is necessary in the case of the standard still, and accordingly requires less building head-room. The chambers of the column are equipped with Lummus boiling caps and trapped return pipes, and the internal reflux system is in all respects similar to that described in connection with the continuous concentrator. All of the reflux tube bundles are removable without dismantling the column. The construction is very simple and durable, with all parts accessible for inspection, cleaning and repairs. The final condenser is of our vertical tubular accessible type arranged for easy cleaning of both inside and outside tube surfaces. This may be accomplished in position by removal of water jacket, vapor bonnet and liquor basin without disturbing connections and set-up of tube bundle. The outfit further includes the usual accessories, such as measuring product gage, recording thermometer, pressure and vacuum safety valves, gage glass, steam trap, etc. We have devoted considerable study during the past four years to the matter of suitable gaskets for benzol and toluol work. As a result, three types of gaskets are now successfully used for this sort of work, according to the nature of the joint to be made up.

Summarized Recommendations

Our recommendations in respect to toluol concentrating and refining are as follows:

Continuous concentration, applied to the preliminary distillation of crude toluol, insures maximum and uniform output. The continuous still once adjusted may be held at top speed production day and night except for occasional interruptions that are likely to occur in the case of all mechanical devices.

The commonly employed batch concentrating process wastes many hours of the day in dumping, charging, heating and cooling. This loss of time is entirely avoided by continuous operation.

The three products—crude benzol, crude toluol and solvent naphtha—are produced simultaneously, instead of one at a time as in the case of periodic operation. The consequent saving of time and increased output are obvious.

The Lummus double column continuous concentrator, including the internal reflux system, insures maximum economy in respect to steam and water consumption and the highest possible concentration of toluol in the crude toluol fraction. Troublesome impurities are eliminated at the start, with consequent saving of time and materials in subsequent operations.

By the interchange of heat between the crude toluol feed-liquor and the hot solvent naphtha discharged from the concentrating process, a material saving of heat is effected, all of which is entirely lost in the present periodic concentrating process. This is an especially important saving as applied to the large volume of crude light oil that must be handled to produce a comparatively small volume of crude toluol, the subsequent periodic refining of which does not involve heat losses of too great consequence.

The chemical washing apparatus, although in accordance with established practice, is of simple, durable construction, careful attention being given to mechanical features and means for preventing undue evaporation losses.

The caustic soda nuisance is eliminated through the use of dissolvers, which operate automatically, without steam or stirring, handling whole cakes rapidly and with minimum attendance.

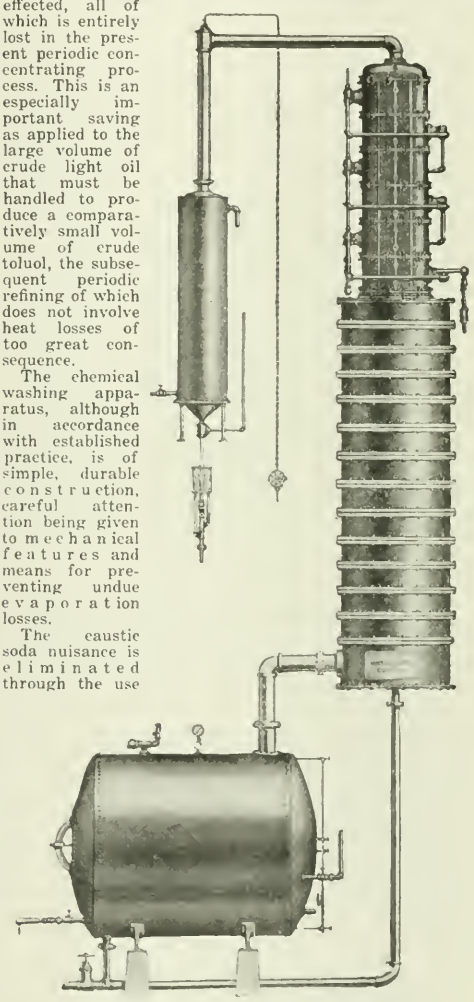


FIG. 12. TOLUOL REFINING STILL WITH PATENT INTERNAL REFLUX SYSTEM

The Lummus periodic refining still, with internal reflux system, operates with high economy of steam and water, effecting sharp separations of objectionable impurities and insuring maximum yield of toluol-pure in one operation.

Needed Improvement of the Chemical Treating Process

We are impressed with the many shortcomings of the thus far unavoidable intermediate refining operation, involving treatment of the crude toluol fraction

with chemicals for the removal of certain impurities that have appeared to be inseparable by distillation alone. Certain remarks in this connection, although perhaps more or less inconclusive, may offer something in the way of a suggestion toward future improvements in this direction. The numerous difficulties inherent in the present method of chemical treatment appear to be sufficiently obvious. At the best, it is an inconvenient and expensive step, worthy of serious effort directed toward its entire elimination or at least drastic improvement. In the first place, usable olefines and valuable phenols, if present, are entirely lost through this process. The consumption of sulphuric acid and caustic soda cannot be disregarded, and the many troublesome features introduced by the necessity of handling these materials, including the regeneration of the acid, add quite a burden to what would otherwise be a fairly clear-cut procedure. The greatest disadvantage of the chemical treatment, however, seems to rest in the unavoidable shrinkage in respect to toluol, not entirely accounted for by the mere removal of impurities other than toluol. This may be explained on the basis of sulphonation and evaporation losses, but the fact remains that valuable toluol disappears, a loss which, under present circumstances, assumes a particularly serious aspect. Furthermore, the process as now carried out, involving the periodic handling of large batches of material, certainly is not conducive to economy; and the skill and judgment demanded on the part of the operator introduces the human element and dependence thereon, which is always an obstacle in the way of efficient production.

We have been devoting considerable thought and work to this problem and feel free to state that progress thus far has been very encouraging. In view of radical departures from usual procedure, we would not consider it advisable to publish at this time the as yet incomplete results of our investigation, and must at the same time acknowledge that our experiments to date are not sufficiently final in their indications to warrant any positive prediction of success. At present we merely wish to call attention to the need of improvements in this quarter, with the hope that later we may be in position to contribute information that may prove helpful in the way of suggesting a practical solution of this problem. Should the completion of our work meet with success, we will report our findings to the proper authorities and then publish, or otherwise make available, such information as may appear generally useful.

Central Concentrating and Refining Stations

In closing this second part of our report, it is desired to comment briefly on the matter of centralized toluol concentrating and refining plants. Assuming the use of tar as the absorbing medium in the absorbing and stripping process, there appear to be no serious obstacles in the way of shipping the recovered crude light-oil fraction to large central stations for concentrating and refining, as required to produce toluol-pure. The fact that the tar makes but one passage through the system means that loss of absorbent, present in the crude light oil, may be disregarded. It stands to reason that the recovery of the light oil is a sufficient strain on the resources of the gas manufacturers, especially if smaller producers are later to be requisitioned; and it would seem undesirable to attempt the more complicated work of concentrating and refining at the various sources of toluol production, because of the large number of small refining units that would be required, which, even under the most favorable circumstances, could not turn out economically the uniform product demanded. On the other hand, a comparatively few very large refining plants, properly distributed throughout the country, could be designed and built to operate with very high economy, in that the very satisfactory results, in no other way attainable, would represent the least expense both in respect to equipment and operating cost. This plan would render possible the use of highly organized apparatus installed in very large units, which, together with scientific control and intelligent supervision, otherwise out of the question, would insure a dependable and uniform toluol production in a high degree favorable to wholesale munitions manufacture. Under any other arrangement, inadequate and inefficient types of apparatus invariably would be resorted to, and the extensive supervision necessary to maintain essential standards seems wholly impracticable. The consequent loss would, in our opinion, amount to appalling figures, due not only to the increased cost of refining, but to actual waste of toluol, measured perhaps in millions of gallons.

We therefore conclude this report with the plea that this matter of centralized refining be given most careful consideration. In fact, the arguments in its favor are so obviously convincing that we are inclined to assume that work, which we understand is already in progress, anticipates refining at large, carefully planned central refineries. These may require extra time to design and build, but in our opinion it would be better to provide extensive storage for crude light oil, produced during the interval, rather than to make the mistake of installing small refining plants for operation by the individual light-oil producer.

Part three, concluding our recommendations in respect to intensive toluol production, will deal specifically with absorbing and stripping plants graded to meet the requirements of various classes of light-oil producers, together with large central refining stations of capacity to handle the light-oil output from their respective districts. It is our hope to include brief schedules of requisite equipment for various plant capacities together with a general idea as to comparative costs.

(To be continued)

Navy Still Needs Binoculars, Spy-Glasses and Telescopes.—The Navy Department has issued a statement announcing that the Navy is still in need of binoculars, spy-glasses and telescopes. The use of the submarine has so changed naval warfare that a greatly increased lookout system is needed. All articles should be tagged, giving the name and address of the donor and forwarded by mail or express to Hon. Franklin D. Roosevelt, Assistant Secretary of the Navy, care of Naval Observatory, Washington, D. C. Articles not suitable will be returned and those accepted will be keyed and returned, as far as possible, at the close of the war. The Government will pay one dollar as rental for each article in order to comply with the law. An attempt will be made to furnish a little historical summary with those instruments which are used and are returned after the war.

Sulphur Dioxide Method for Determining Copper Minerals in Partly Oxidized Ores*

By CHARLES E. VAN BARNEVELD and EDMUND S. LEAVER

MILLING practice at the porphyry copper mines of the Southwest is in a transition stage because of the rapid changes following the introduction of flotation. Among the several problems that are receiving earnest attention from the operating companies is the recovery of the copper minerals forming the complex ores of the oxidation zone of the deposits.

This problem is under investigation at the Tucson experiment station of the Federal Bureau of Mines. A survey of the status of present laboratory practice brought out the need of a correct and rapid method for the selective determination of the quantity of copper in the sulphide form, on the one hand, and of that in the form of combined oxides, carbonates, silicates, and native or metallic copper, on the other hand, in partly oxidized ores and in mill products from these ores. Such a method is necessary for control determinations on flotation mills treating sulphide ores and also on lixiviation works using either acids or alkalines as the active solvent for the copper in oxidized and silicate form. For convenience in this report such copper is termed "oxidized copper."

Sources of Error in Methods in Use

The methods in common use for selective determination of copper minerals are the sulphuric acid method and the ammonia method. Both are unsatisfactory.

SULPHURIC ACID METHOD

The sulphuric acid method, in which a 5 per cent solution of cold sulphuric acid is used to dissolve all the oxidized copper, is unreliable for several reasons. A certain amount of metallic iron (ranging from one-tenth to one-half of one per cent) is nearly always present in the sample, introduced by the various crushing (mill) and pulverizing (laboratory) processes. This metallic iron precipitates more or less metallic copper from the copper sulphate solution formed by leaching with dilute sulphuric acid, thus giving correspondingly low oxidized copper returns. Another source of error in the same direction is the fact that dilute sulphuric acid dissolves only one-half the copper present as cuprite (Cu_2O). A serious source of error in the opposite direction, making for high oxidized returns, is the fact that chalcopyrite, bornite, and chalcocite are more or less soluble in dilute sulphuric acid (see Table I). Hence, more or less copper in sulphide form is reported as oxidized copper. It sometimes happens that the plus error due to solution of some of the copper in sulphide form is largely compensated by the minus error due to partial solution of cuprite and to deposition of copper on metallic iron. The majority of the ores tested by the writers show high oxidized and low sulphide returns, and check samples show considerable variation.

*Contribution from the Tucson Station, U. S. Bureau of Mines. Printed by permission of the Director.

The results of tests with chalcocite and chalcopyrite, showing the solubility of the copper content in different reagents, are presented in Table I.

TABLE I—RESULTS OF LEACHING CHALCOCITE AND CHALCOPYRITE WITH 5 PER CENT SOLUTIONS OF DIFFERENT REAGENTS

The mixtures were agitated two hours on a bottle-rolling machine. Five grams of pure mineral was used for each of the mesh sizes indicated

Mesh	Proportion of Copper Content Leached from Chalcocite with Solution: Sulphuric Acid, per Cent	Chalcocite with Solution: Ammonia and Ammonia Carbonate, per Cent	Chalcocite with Solution: Sulphur Dioxide	Chalcopyrite with Solution: Sulphuric Acid, per Cent	Chalcopyrite with Solution: Ammonia and Ammonia Carbonate, per Cent	Chalcopyrite with Solution: Sulphur Dioxide
20 to 40	0.11	3.87	None	0.03	0.12	None
40 to 65	0.28	7.50	Do.	0.04	0.18	Do.
65 to 100	0.36	14.10	Do.	0.06	0.21	Do.
100 to 150	0.60	16.60	Do.	0.15	0.32	Do.
150 to 200	0.82	17.10	Do.	0.17	0.45	Do.
200 to	2.07	22.70	Do.	0.56	0.93	Do.

AMMONIA METHOD

The ammonia method, in which a 5 per cent solution of either ammonia or of ammonia and ammonium carbonate is used to dissolve the oxidized copper, is even more unreliable than the sulphuric acid method. The results in Table I show that both chalcopyrite and chalcocite when pulverized are decidedly soluble in solutions of ammonia and ammonium carbonate, the finer the material is ground the greater is the degree of solubility. On the other hand, complete solution of the oxidized copper is rarely attained. This defect is most noticeable in ores having a siliceous gangue and in ores carrying chrysocolla. The solvent gelatinizes the silica and it appears that the formation of this gelatinous, spongy mass prevents complete decomposition of some of the copper mineral, in addition to holding dissolved copper during filtration.

Sodium Tartrate Method

While the investigation at the Tucson station was in progress, an improved method was developed by H. D. Hunt and R. V. Thurston, of the research laboratory of the Miami Copper Co. This method was brought to the writers' attention after the completion of their own work on the sulphur dioxide method described in this paper. A description of Hunt and Thurston's, which may be called the sodium-tartrate method, has been published in the September, 1917, issue of the Colorado School of Mines Magazine.[1] The procedure is essentially as follows:

PROCEDURE

Place 2 grams of pulp in a beaker, add 20 cc. of a

[1] Hunt, H. D., and Thurston, R. V. The determination of oxidized copper in ores. Colorado School of Mines Mag., Vol. 7, September, 1917, pp. 157-158.

solution of caustic soda-sodium tartrate, and boil the mixture gently 5 to 10 minutes with occasional shaking of the beaker. To the hot mixture add 25 cc. of a 20 per cent solution of ammonium sulphate; heat for 10 minutes. Filter; wash several times with a hot solution of ammonium hydroxide and ammonium sulphate, and finish the washing with hot water. Neutralize the filtrate with sulphuric acid and add 2½ cc. of concentrated nitric acid. It is now ready for electrolysis.

The first treatment with solution of caustic soda and sodium tartrate effects complete and rapid solution of the azurite, malachite, and melaconite, and partial solution of the cuprite. The rest of the cuprite is dissolved later. The chrysocolla also goes into solution. Care must be taken not to boil to dryness or to a small volume. The reagent must be of sufficient strength to redissolve the copper hydroxide first formed by the action of the solution on the oxidized copper minerals in the sample. The ammonium sulphate solution has a two-fold function. It converts the excess sodium hydrate into sodium sulphate and it forms ammonium hydroxide which dissolves any remaining cuprite.

SOLUTIONS REQUIRED

The following stock solutions are required: Sodium hydrate-sodium tartrate solution, consisting of 100 grams of sodium hydrate and 50 grams of sodium tartrate dissolved in 1000 cc. of distilled water; ammonium sulphate solution, consisting of 250 grams of ammonium sulphate in 1000 cc. of distilled water; and ammonia-ammonium sulphate solution for washing, prepared by adding 100 cc. of ammonium hydroxide and 100 grams of ammonium sulphate to 1000 cc. of distilled water.

POSSIBLE SOURCES OF ERROR

In testing out this method, the writers found that it gives fairly satisfactory results on the low-grade porphyry ores for which it was developed. The method is, however, subject to two well-defined inaccuracies.

One of these arises from the fact that chalcocite is decidedly soluble in ammonia. Washing with hot solution of ammonia and ammonium sulphate unquestionably dissolves more or less copper in the form of chalcocite from the mass on the filter paper. Several tests were made of 2-gram samples containing 3 to 4 per cent of oxidized material and varying proportions of chalcocite. Mixtures containing 8, 16, and 24 per cent copper as chalcocite showed respectively 0.18, 0.33 and 0.45 per cent dissolved in washing and erroneously reported as excess oxidized copper.

Another source of inaccuracy as regards ores containing chrysocolla, results from the difficulty of washing all the dissolved copper from the gelatinized spongy mass on the filter paper. Mixtures containing 2½ to 3 per cent copper as chrysocolla showed losses ranging from 0.05 to 0.1 per cent; and mixtures containing 5 and 7½ per cent in this form, respectively, showed losses of 0.33 and 1.42 per cent. These errors tend to balance each other for ores containing both chalcocite and chrysocolla in small amounts. In analyses of ores containing less than 5 per cent copper, the resultant error (see Table II) is not serious.

Sulphur Dioxide Method

The experiments with the sulphur dioxide method were made with the following requirements in mind:

1. The method must be applicable to a wide range of ores, and must be thoroughly reliable and rapid.
2. Copper sulphides, especially the more easily decomposed chalcocite, must not be affected by the reagent used.
3. Metallic iron must not affect the determination.

The method evolved is based on a large number of experiments, the results of which show conclusively that cuprite, melaconite, malachite, azurite, chrysocolla, and metallic copper, when finely pulverized, are readily and completely soluble in sulphur dioxide solution (sulphurous acid). Copper sulphides are not attacked, no matter how finely pulverized the mineral may be nor how long the time of contact. The two essential features of the method are: (1) fine pulverization in order to completely free the particles of copper minerals from the gangue; (2) the powdered mineral must be kept in suspension by shaking or rolling during the lixiviation or solution period.

PROCEDURE

The procedure in the sulphur dioxide method is as follows: Place 2 grams of pulp ground to a fineness of 100 to 150 mesh in a bottle, add 100 cc. of a 3 per cent solution of sulphur dioxide. Seal the bottle and agitate by rolling ½ to 2 hours. Filter; wash the residue with sulphur dioxide solution; add the washings to the filtrate, which will contain in solution all oxides, carbonates, and silicates of copper and all metallic copper. Add 5 to 10 cc. of nitric acid. Boil down to 20 cc. Dilute with distilled water to 150 cc. and determine the copper by the electrolytic method in the usual way.

The residue from filtration contains the unaltered and undissolved copper sulphide. In the experimental work the copper present as sulphide was separately determined in order to check the determination of oxidized copper. Ordinarily this step would not be necessary. In analyses of the low-grade porphyry copper ores of the Southwest, the sulphides may be readily decomposed and all the copper dissolved by proceeding as follows: To the residue add 5 cc. of sulphuric acid and 10 cc. of nitric acid and boil until dense white fumes appear. Add 5 cc. of nitric acid and dilute with distilled water to 150 cc. Determine the copper by the electrolytic method. This method of determining copper in the residue is not suited for heavy sulphide ores containing interfering bases, and for such ores standard methods should be used.

PREPARATION OF SOLUTION

Although sulphur dioxide solution (sulphurous acid) may be readily purchased, it is decidedly unstable; hence the solution should be prepared in the laboratory as needed. Small quantities are easily made by adding moderately strong sulphuric acid to scrap copper tinned on one side; the resulting sulphur dioxide gas is absorbed in water. For continuous work it is better to purchase liquid sulphur dioxide in steel cylinders and drums, which are obtainable in sizes ranging from 6-pound to 200-pound capacity. In the first experiments at the Tucson station the sulphur dioxide gas was introduced directly into the bottle containing the water and pulp. Much loss of gas resulted and the procedure was otherwise unsatisfactory.

Later the simple apparatus shown in Fig. 1 was evolved. The absorption tower *a*, 43 inches long, made

of ¾-inch to 1-inch glass tubing and filled with broken hard-burned fireclay, is set at an angle of 75 deg. between two glass bottles, *b* and *d*, of 3 to 5 gallons capacity, the bottle *b* being placed about 5 feet above the other bottle. The tower is open at the top and sealed at the bottom with a plug of sealing wax, *e*, through which two small glass tubes extend. The upper bottle, *b*, contains distilled water which is siphoned into the upper end of the absorption tower, the flow being regulated by a stop cock, *f*. A cylinder *c* (capacity 6 to 50 pounds) containing liquid sulphur dioxide is connected to one of the glass tubes extending into the absorption tower. On opening the valve of this cylinder the liquid sulphur dioxide issuing from the valve is gasified by the reduction in pressure and passes into the tower, where it is absorbed by the water from bottle *b*, converted into SO_2 solution of the desired strength and caught in the stock bottle *d*.

This apparatus gives entire satisfaction. With little attention a 3 per cent solution of sulphur dioxide may be produced at the rate of 3 liters per hour. The cylinder containing liquid sulphur dioxide, indicated in the sketch, may be replaced with a gas generator.

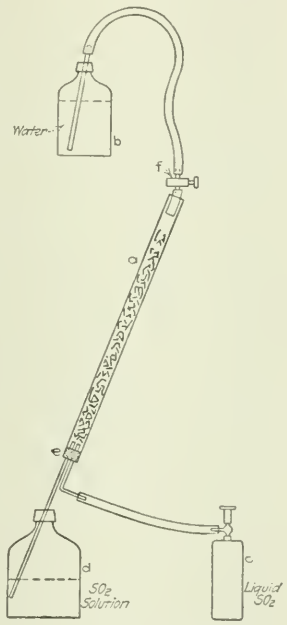


FIG. 1. APPARATUS FOR PREPARING SO_2 SOLUTION

STRENGTH OF SOLUTION AND TIME OF CONTACT

Considerable variation as regards strength of solution and time of contact will be necessary in treating different ores from different localities. In general, a solution containing 3 per cent SO_2 should be used. With some ores much weaker solutions, as low as 0.75 per cent SO_2, will do the work. Merely introducing the pulp into the solution, shaking the bottle for a few minutes, and letting it stand, will not dissolve the copper; constant agitation is essential. For a small number of tests a bottle-agitating machine will give satisfactory results. For analytical work where large numbers of samples are run, as in a mine laboratory, a bottle rolling machine will be found more satisfactory, not only for this purpose but for all solutions requiring constant agitation. The time of contact necessary to completely dissolve the oxidized copper minerals was found to vary from ½ to 2 hours. Most of the ores and products tested gave complete recovery in half an hour and the most refractory ores yielded in less than two hours.

To determine the strength of the sulphur dioxide solution, the following adaptation of a well known reaction is recommended; it is based on the fact that introducing either weak or concentrated sulphurous acid into a solution of iodine will result in the complete oxidation of the sulphur dioxide.

Prepare an iodine solution by dissolving 16.8 grams of potassium iodine in distilled water, adding 8.4 grams pure resublimed iodine, and shaking until the iodine is completely dissolved. The more concentrated the potassium iodide solution, the more readily will the iodine dissolve. Bring the solution to proper strength by adding enough distilled water to make a volume of 1 liter, and standardize by the thiosulphate method.

The determination is made as follows: To a measured quantity of standard iodine solution add slowly with constant stirring the proper volume of sulphur dioxide solution. So regulate the volume of iodine solution used that the mixture always contains a decided excess of iodine over the quantity required to oxidize the sulphur dioxide being added. An excess of sulphur dioxide causes the solution to clear and to lose its dark red color. If an excess of sulphur dioxide is added the determination is spoiled, and the test should be repeated with fresh sulphur dioxide solution and larger quantity of iodine solution. Thus, there is a direct ratio between the strength and quantity of sulphur dioxide solution and the quantity of standard iodine solution. In general, for solutions containing 1 to 3 per cent sulphur dioxide 1 cc., and for weaker solutions 20 cc., of standard iodine solution should be used. The mixture is then titrated by the thiosulphate method to determine the quantity of iodine remaining in the mixture. The difference between this quantity and the total quantity of iodine represents the iodine used in oxidizing the sulphur dioxide. The strength of the sulphur dioxide solution may then be calculated according to the formula:

$$SO_2 + H_2O + 2I = 2HI + SO_4$$

COMPARISON WITH OTHER METHODS

Comparative results obtained with the four methods described on ores and mill products from the Morenci,

TABLE II—RESULTS WITH THE FOUR METHODS COMPARED

Source of Sample	Copper Content Per Cent	Oxidized Copper (Oxide, Carbonate and Silicate): By Sulphur Dioxide Method, Per Cent	By Sodium Tartrate Method, Per Cent	By Sulphuric Acid Method, Per Cent	By Ammonia Method, Per Cent
Inspiration mill feed	1.31	0.35	0 33	0.41	0.36
Inspiration mill slimes	0 43	32	28	.35	.07
Miami complex ore	2 24	1 05	1 02	1.32	.91
Morenci mill sand	.61	.09	07	.23	.09
Morenci mill slimes	52	.20	18	.26	.04
Ray mill sands	47	04	03	18	.12
Ray mill slimes	52	27	.25	.32	.22
Chino mill heading	1 18	19	.19	.52	.24
Chino mill tailing	45	13	.15	.31	02
Chino mine ore	2 49	95	.94	1 18	1 12
New Cornelia Ajo ore	1 26	42	42	76	22
Ruth mill heading	1 65	25	29	41	49
Giroux mill tailing	58	01	02	08	04
Nevada Con mill heading	82	07	05	30	25
Nevada Con mill tailing	83	02	03	08	04
Utah copper mine ore	2 53	24	26	57	50
Utah copper mill feed	89	60	56	63	37
Utah copper mill tailing	63	07	06	11	09
Miami ore, special test:					
20 mesh	2 25	1 06	0 96	1 18	0 83 to 0 90
48 mesh	2 25	1 05	0.98	1 28	0 62 to 0 98
65 mesh	2 25	1 08	1 00	1 30	0 95 to 1 10
100 mesh	2 25	1 06	0.97	1 32	0 91 to 1 10
150 mesh	2 25	1 07	0.92	1 32	0 92 to 1 06
200 mesh	2 25	1 06	1 02	1 34	0 88 to 1 09

Note.—In the sulphur dioxide method any metallic copper present would be reported as oxidized copper. In the other three methods, metallic copper would be reported as sulphide.

Globe, Ray, and Ajo districts in Arizona, from Chino, from Bingham, Utah, and from Ely, Nev., are presented in Table II. The table shows that, compared with the sulphur dioxide method, the results for oxidized copper are high with the sulphuric acid method and low with the ammonia method. The sodium tartrate method shows uniformly and slightly lower returns. The last sample in the table, designated "Miami ore, special test," was crushed to 20-mesh size, special care being taken to prevent overcrushing. Five portions were then taken and crushed with the same care to the successive sizes listed. The uniform results for oxidized copper by the sulphur dioxide method is evident. The results with the sodium tartrate method, which was developed on this class of ore, show more variation and are slightly lower. The sulphuric acid method shows high returns, which are progressively higher for the finer sizes. Results with the ammonia method are low and show considerable variation.

Conclusions

Sufficient work has been done with the sulphur dioxide method to substantiate the following claims:

1. Cuprite, melaconite, malachite, azurite, chrysocolla, and metallic copper are dissolved rapidly and completely.
2. Chalcocite and chalcopyrite are not affected.
3. Metallic iron in ordinary quantities, even up to 3 per cent, dissolves rapidly and has no effect on the determination, provided there is a strong excess of SO_2.
4. There is no gelatinization of silica, and the possible loss of copper from this cause, noted in analyses by the other methods described, is eliminated.
5. The method is applicable alike to high-grade and low-grade ores. The manipulation is simple and the possible sources of error are few. One chemist can keep a 6-unit electrolytic outfit working to full capacity on porphyry ores.
6. Any metallic copper present would be reported with the oxidized copper. If a separate determination of metallic copper is considered necessary this may be made by amalgamation, preferably in an amalgamated copper pan.
7. Crushing fine enough to liberate completely the mineral particles is essential. Ores containing an appreciable proportion of chrysocolla should always be pulverized to 150 mesh.

Manganin.—Mr. M. E. Leeds of Leeds & Northrup, Philadelphia, states that manganin is difficult to obtain and is not to be had in any desirable quantities. At least one of the substitutes offered for it by an American manufacturer is, however, fully as good as manganin. It is, however, equally difficult to get, and, to the best of his knowledge, is not being produced in any sufficient quantity. There are probably several American manufacturers of alloys who could produce as good manganin as that made in Germany, and it is not so much research that is needed to help us out of the situation as it is greater productive capacity for special alloys. The manufacturers who are competent to make manganin are so overworked with orders which the Priority Board would probably consider more important that it is very difficult to get them to take the matter up.

Synopsis of Recent Metallurgical and Chemical Literature

Manganiferous Iron Ores.—U. S. Geological Survey Bulletin 666-EE by E. C. Harder gives valuable data on the deposits of manganiferous ores in the United States and their possible utilization. The dependence of the United States on imported high-grade manganese ore and ferromanganese is well known to steel makers and other users of manganese. Normally the high-grade manganese ore produced in this country constitutes less than 2 per cent of the total amount of manganese ore consumed, not including the ore represented by the manganese imported in the form of the alloys ferromanganese and spiegeleisen. During 1916 the domestic production was about three times that of 1915, largely on account of the high prices paid for ore. The exploration for new deposits has also been stimulated, and many discoveries of manganese ore are being reported. Even with this outlook for increased production, however, the author thinks it not unduly pessimistic to say that the deposits of high-grade manganese ore in the United States will probably never be able to supply the manganese consumed in domestic industries. If, therefore, the importation of high-grade manganese ore were discontinued, numerous industries would be vitally affected. Of these the steel industry consumes by far the largest quantity of manganese. The author, after giving a description of the deposits in the United States and the production of the various states, summarizes his report as follows:

There are in the United States large quantities of manganiferous ores containing varying amounts of manganese. A very small proportion of these can be used in the production of high-grade iron-manganese alloys, but a large proportion can be used for lower-grade alloys, and nearly all can be used in making high-manganese pig iron. Compared with the manganiferous ores, the reserves of high-grade manganese ores in this country are insignificant. Hence, although a search for manganese ore is desirable, a more promising solution of the manganese problem would seem to lie in the direction of the utilization of low-grade manganiferous ores. Up to the present time the use of these ores has been very slight. Until a few years ago they were considered to have little value and were mined only incidentally. In the West manganiferous ores would not be mined were it not for their association with ores of other metals.

There are several ways in which the utilization of manganiferous ores may be brought about: (1) It has been suggested that by methods of concentration resulting in the elimination of iron, silica, or other constituents a product high in manganese might be derived from them. Such concentration has been attempted locally but with very little success, owing mainly to the intimate mixture which manganese generally forms with associated materials. (2) The steelmaking practice might be changed so that more spiegeleisen and less ferromanganese would be used for deoxidizing. By the addition of small quantities of high-grade manganese ore much of the manganif-

erous iron ore could be used in the manufacture of spiegeleisen. (3) The most effective solution, however, as has previously been suggested, seems to be to so change the practice in the manufacture of basic open-hearth steel as to make possible the use of high-manganese pig iron. Experimentation along this line is extremely desirable. The successful application of such a change would make large reserves of manganiferous iron ore commercially available and would greatly decrease the quantity of high-grade manganese ore consumed.

Ball Mill Tests at Inspiration.—Mr. C. T. VAN WINKLE, in a paper to be presented at the New York Meeting of the American Inst. of Mining Eng., February, 1918, on "Recent Tests of Ball-Mill Crushing," gives some hitherto unpublished data on the test conducted at the Inspiration mill at Miami, Ariz., early in 1916, when two sections were added to the mill. After outlining the experience of the Miami Copper Co. (Franke, Trans. A. I. M. E., Vol 47, page 50) and early work by Dr. Gahl at Inspiration (Trans. A. I. M. E., Vol. 55, page 576, and *Metallurgical & Chemical Engineering*, Vol. 15, page 393), the author continues:

"Early in 1916 the Inspiration company decided to add two sections to its mill, and an offer by Mr. Hardinge to equip a section with two of his mills without cost to the company was accepted. These mills were expected to do the work of the same number of Marcy mills, with much less power.

This test was begun April 4, 1917. A section comprising two 8-ft. Marcy mills equipped with 225-hp. motors, which had been in continuous operation since January, 1917, was used in comparison with a section comprising two 8-ft. Hardinge mills equipped with 150-hp. motors. Each of the Marcy mills took the original feed from the bin and, in closed circuit with a 6-ft. Dorr classifier, made a finished product.

The Hardinge mills were first arranged in tandem, the first mill taking all of the coarse feed, its product going to a Dorr classifier, the sands from which passed to the second Hardinge mill working in closed circuit with the second Dorr classifier. Each of the sections was equipped with an automatic scale so that the total or the hourly tonnage could be recorded and noted. The crushed product, the overflow from the Dorr classifiers, was carefully sampled in each case by automatic samplers. The daily report sheets of the finished product showed some variation from the desired 2 per cent on 48-mesh with both types of mills, but by applying a correction factor the final results, as tabulated, could be reduced to the basis of 2 per cent on 48-mesh. This correction factor was derived by Dr. Gahl from actual operating experience. The screen analysis of the feed was published in the *Engineering and Mining Journal*, September. 1916. The results are as tabulated below:

The daily reports show that various ball charges and various sizes of balls were used in the Hardinge mills; that the speed of the Hardinge was changed a number of times; various types of scoop feeders were used; the delays due to overloading the Hardinge mill, changing balls, etc., as mentioned, were very great. The Marcy mill continued with its ball load unchanged and practically without delays.

The record shows that the capacity of the Marcy mill was 130.5 per cent greater than the Hardinge, and the Marcy saving in power over the Hardinge was 34.04 per cent. At times the motors of both types of mills were slightly overloaded. As the power was measured by integrating wattmeters, this does not affect the results and comparisons given. The figures showing daily tonnage and kilowatt-hours per ton are averaged from the daily report sheets issued by the Inspiration management. These figures were accepted by the manufacturers of both mills, and there is no doubt as to their correctness.

Marcy Section		Hardinge Section	
Duplicate mills, 8 ft. by 72 in.		Duplicate mills, 8 ft. by 36 in.	
Spiral scoop feeders		Spiral scoop feeders on both primary and secondary mill	
Lining, Mn steel, Krupp type		Lining, Cr steel	
Grates, Cr steel, ¾-in. openings		Speed, 26 r.p.m.	
Speed, 24 r.p.m.		Motors, 150 hp.	
Motors, 225 hp.		Cr steel balls of following sizes:	
Cr. steel balls of following sizes:		Primary	Secondary
2¾ inches	1,880 lb.	5 in. 13,000 lb.	2 in. 14,500 lb.
2½–3 inches	7,290 lb.	4 in. 10,500 lb.	1½ in. 10,500 lb.
3 –3½ inches	15,445 lb.	3 in. 8,500 lb.	1 in. 7,000 lb.
	29,890 lb.	32,000 lb.	32,000 lb.
Weight of each mill (empty) and motor = 85,000 lb.		Weight of each mill (empty) and motor = 40,000 lb.	
Duplicate Dorr classifiers, 6 ft. by 26 ft. 7¾ in.		Duplicate Dorr classifiers, 6 ft. by 26 ft. 7¾ in.	

	Marcy	Hardinge
Daily tonnage (dry), corrected to 2 per cent. on 48-mesh	1118	485
Kw.-hr. per ton crushed	8.52	11.42

No ball consumption was published by the Inspiration company on the Hardinge mills because many changes had been made in the ball load. The operation of the Marcy mills was in charge of the regular mill crew, while that of the Hardinge section was under the supervision of Mr. Hardinge and his assistants, who were at the plant from April 4 to June 11, when the test was discontinued. The ball consumption of the Marcy mill in the entire plant is 1.7 lb. of steel for each ton of ore crushed.

Determination of Temperatures by Eutectic Alloys.—In the Journal of the American Chemical Society for January, 1918, Dr. C. P. STEINMETZ of the General Electric Co. gives the results of some observations on the use of eutectic alloys in temperature determinations. He says the foremost advantage expected was the far greater independence of their melting point from the purity of the material. Any impurity, such as an excess of one or more constituents, should, in cooling, crystallize out when the freezing point is approached and the alloy thus thickens before solidifying, but the final freezing point remains that of the eutectic alloy. From experiments made on various alloys with melting points below 200 deg. C., it was found, however, that material impurities caused by metals which are not a constituent of the alloy may be harmful and are to be guarded against, but a considerable deviation of the proportions of the normal constituents of the alloy appears harmless. Even the harmful effect of a foreign metal impurity probably is limited to the cases where the addition of such metal forms a eutectic alloy of lower melting point. The following twelve alloys were found by the author in the range below 200 deg. which are eutectics or sufficiently near to eutectics in their composition to permit their use, and their melting points determined by observing the freezing curves, while stirring with the thermometer. A number of observations were made with each alloy, with slightly changed composition, and by interpolation the composition of the true eutectic estimated and checked by its freezing curve.

However, neither time nor facilities were available to go very far in the investigation, and the values given in the following table thus are only approximately those of the eutectic. It would be of interest to determine the exact composition of the eutectic. This could most conveniently be done by studying the shape of the cooling curve. In the eutectic, the curve of decreasing temperature of the melted alloy follows an approximate exponential down to the constant freezing temperature. If, however, the composition is not exactly eutectic, the cooling curve deviates from the exponential when approaching the freezing point, and the temperature decreases more slowly, while the non-eutectic part freezes out.

Low Melting Eutectic Alloys
(Approximate)

Melting point	Composition						Remarks	Temp. of undercooling
	Bi.	Cd.	Pb.	Sn.	Tl.	Zn.		
69.5[1]	15	3	8	4	..	..	slightly ductile	64°
90.0	7	1	6	..	..	..	ductile	83
93.5[2]	2	..	1	1	..	..	moderately ductile	91
102.4	11	4	..	5	..	..	brittle	96
132.0	11	..	9	..	..	..	ductile	127
132.5	2	..	..	1	..	..	brittle	..
143.5[3]	2	1	..	..	..	..	brittle	137
144.8[4]	..	2	5	3	..	..	ductile	137
166.5	..	..	..	4	3	..	ductile	..
172.0	..	1	..	2	..	..	ductile	..
178.3[5]	..	..	3	5	..	..	ductile	175
194.0	..	..	..	10	..	1	ductile	..

[1]Wood's metal, expands after cooling.
[2]Rose metal, expands after cooling.
[3]Combustible above melting point.
[4]Cadmium solder. Lowest melting alloy not containing the expensive bismuth.
[5]Tin solder.

It is interesting to note that the alloys which do not contain bismuth are ductile, while the alloys containing bismuth are brittle, unless they contain a large percentage of lead and little if any tin or cadmium.

Effect of Hydrochloric Acid on the Nitrogen-Hydrogen Equilibrium.—At a recent meeting of the Faraday Society in London, Dr. E. B. Ludlam presented the results of an experimental attempt to simplify the difficult conditions of high temperature at high pressure under which the Haber synthesis of nitrogen and hydrogen to form ammonia takes place. Deville long ago proved that ammonia in the presence of hydrochloric acid gas was more stable than when alone, and it was therefore thought that the presence of hydrochloric acid during the synthesis would displace the equilibrium in the direction of the formation of ammonia by preventing the reverse change, and would remove the ammonia so quickly that the synthesis might be possible at atmospheric pressure. Some preliminary experiments gave negative results, and further showed that the problem of finding a catalyst suitable for use in the presence of hydrochloric acid was likely to prove a great difficulty. In later experiments the equilibrium was studied by attempting the reverse operation, that is, starting from ammonium chloride and decomposing it into nitrogen, hydrogen and hydrochloric acid. Various catalysts were used, but only iron gave positive results. The presence of ferrous chloride, however, introduced a new factor, and its volatility at a low temperature was a serious drawback. In any case the final equilibrium at 800 deg. C. was not displaced to any very considerable extent, and the direction of the formation of ammonia by the presence of hydrochloric acid. The result of the experiments, as far as they went, were therefore negative.

Recent Metallurgical and Chemical Patents

Catalyzers.—Four patents have been issued to Carleton Ellis, of Montclair, N. J., on catalyzers. The first relates to a finely divided catalyzer made by heating organic compounds such as oleates of catalytic metals, in the oil to be catalyzed. These organic compounds may be decomposed, setting free the catalyst (that is the metal) not as a pulverulent catalyzer, but as an oil colloid, the metal existing therein in a state of almost infinite subdivision, perhaps approaching molecular condition, and colloidally carried in a state of quasi solution, conducive to accelerated hydrogen absorption by the fatty or other organic materials. The second patent relates to nickel carbonyl. The third patent relates to a process of making a catalyst comprising the reduction of an organic nickel salt such as nickel acetate with a reducing gas. The fourth patent relates to a process of heating, while sealed from contact with air, a mixture of an organic compound of nickel or a metal having an atomic weight between 51 and 63.6, and a nitrate of the metal. A reduction takes place and metallic nickel or other metal used is produced. (1,251,201-2-3-4, Dec. 25, 1917.)

Metallic Alloys.—F. M. Becket of Niagara Falls, N. Y., has patented two alloy compositions (assignor to Electro Metallurgical Co.). The first calls for an alloy essentially of

Chromium	.....25 - 30	per cent
Carbon	..... 1.5 - 3	per cent
Silicon	..... 0.0 - 3	per cent
Iron	.....73 - 63.5	per cent

forming metal of extreme toughness, hardness and freedom from oxidation and rusting. The resistance to rusting increases with the silicon, although higher silicon induces brittleness. One of the alloys resisted an oxidizing atmosphere at 1100 deg. cent. continuously for two weeks without appreciable oxidation. The alloys are markedly fibrous, can be forged, annealed, tempered and machined, and are useful as an abrasive, as non-slipping surfaces, for turbine blades, cutting tools, and high temperature work. (1,245,552, Nov. 6, 1917.)

The second alloy is of iron and cobalt approximately in the proportions of the formula Fe_2Co, with from 2 to 6 per cent of silicon, which produces a metal characterized by low hysteresis and high magnetic saturation values. These magnetic advantages increase roughly with the silicon content, and therefore the latter is kept as high as possible without destroying the malleability. Carbon is kept as low as practicable. (1,247,206; Nov. 20, 1917.)

Hans Goldschmidt and Otto Weil of Germany (assignors to Goldschmidt Thermit Co.) patent a method of forming high-percentage tungsten alloys. These are usually produced in electric furnaces, and therefore contain a percentage of carbon, sometimes prohibitive for certain uses. Former attempts by alumino-thermic reactions were unsuccessful, causing large slag losses of the refractory tungsten. Contrary to expectation, good yields by the latter method were obtained by adding indifferent substances to the reacting mixture.

such as lime or fluor-spar, in quantity up to one-quarter of the tungstic oxide used. (Purified scheelite, $CaWO_4$, may evidently also be used.) This process may be used for incorporating tungsten or its alloy into molten metal baths, by merely adding a mixture of ferric oxide, tungstic oxide, aluminium, and lime. The pure ferrotungsten produced immediately alloys without waste, and the easily fusible slag remains liquid on the surface of the bath. The method is claimed to be superior to that of adding pulverized metallic tungsten or ferrotungsten in that no carbon or oxidized impurities are added to the melt, and the waste in non-alloyed tungsten is much reduced. (1,235,969, Aug. 7, 1917.)

Production of Iron Sulphide.—A process for making iron sulphide is patented by N. G. PETINOT of New York City and assigned to the United States Alloys Corporation of New York. One method which has been used is that of heating together, at a high temperature, a mixture of three parts of iron filings and two parts of sulphur in a covered crucible. Another method is to heat together a mixture of iron sulphide and iron filings in a crucible until the whole mass was fused. Still another is that covered by U. S. Patent No. 1,169,093, issued to Mr. Petinot on Jan. 18, 1916, which consists in heating, in an electric furnace, pyrites ore containing silicious or other impurities sufficient to produce a slag, and sufficient iron to form ferrous sulphide according to the following equation:

$$FeS_2 + Fe = 2FeS.$$

The patentee states that while the last mentioned method of manufacture is better than any heretofore employed, he has found that a considerable quantity of sulphur is lost by vaporization, in spite of the protecting blanket of slag, which is formed during the working of the furnace. Moreover, the operation of the furnace is not continuous, because after the charge is fused and the chemical reaction referred to above is completed, the furnace must be tapped so as to draw off the ferrous sulphide and also the slag, and then introduce a fresh charge.

In the present process iron pyrites is used with a mixture of oxide of iron in such proportions that, when the mixture is fused, reaction occurs between its constituents. This reaction is represented by any one of the following equations:

$$3FeS_2 + 2FeO = 5FeS + SO_2$$
$$5FeS_2 + Fe_2O_3 = 8FeS + 2SO$$
$$7FeS_2 + 2Fe_2O_3 = 11FeS + 3SO_2$$

The mixture is, therefore, made up so as to correspond to the reactions given above; the proportions depending upon the analysis of the iron oxide used for the purpose in view. The mixture is fused in an electric furnace preferably of the Siemens type.

When the mixture is fused, the reaction occurs as indicated above, and the iron sulphide (FeS) accumulates in the bottom of the crucible, while the fused mixture of pyrites and iron oxide that still remain in their unreduced condition at the top of the furnace, form a pseudo-slag. When sufficient iron sulphide has accumulated in the crucible, it is tapped without shutting down the furnace. The furnace may also be charged without stopping the process, thus making the method of manufacture a continuous one.

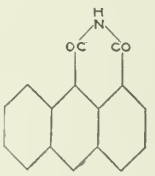
The patent states that while it is true, as indicated by the reactions shown in the equations given above, that sulphur is lost in the form of SO_2, it is to be noted that this sulphur has a useful function as a reducing agent. This sulphur removes the oxygen from the iron oxide, whereas, in the previously mentioned patent, the sulphur is lost by vaporization and, therefore, performs no useful work. (1,252,024, Jan. 1, 1918.)

Dyestuffs

Bluish-Green Vat Dyes.—MICHAEL KARDOS of Charlottenburg, and PAUL NARVIASKY of Ludwigshafen, Germany, patent a process of making certain vat dyes. The patent is assigned to the Badische Anilin & Soda Fabrik. The dyes referred to fall in a class patented under Patent No. 1,216,134, but are not specifically described in that patent. That patent claims the specific coloring matter obtainable by melting anthracene-1.9-dicarboxylic acid imid with caustic alkali, and states that this specific coloring matter yields a cherry-red vat and dyes cotton a beautiful full green. This specific dye apparently possesses an unsubstituted imid group.

The class of coloring matters described in the present patent are characterized by possessing a substituted imid group by giving from red to violet vats with alkaline hydrosulphite solutions and by yielding bluish-green shades on cotton; that is to say, they yield more bluish shades of green than does the coloring matter obtainable from anthracene-1.9-dicarboxylic acid imid.

They can be obtained by subjecting to the action of molten caustic alkali an anthracene-1.9-dicarboxylic acid imid corresponding to the formula



in which the hydrogen of the imid group has been substituted, for instance, by hydroxyl, or alkyl, or aryl. Other methods are also described. (1,253,252, Jan. 15, 1918.)

Miscellaneous Chemical Processes

Alcohol Manufacture.—BURRITT S. LACY of Sewaren, N. J., proposes to produce alcohols of the paraffin series, such as methyl alcohol, by treating alkyl halogens, such as methyl chloride, with hydroxides or carbonates of the alkaline earths. The conditions for the reaction between lime and methyl chloride are given as follows:

"(1) That the methyl chloride gas, the solution and the solid lime be vigorously and continuously agitated together.

"The probable explanation of the necessity of this is that the reaction occurs only in solution, *i.e.*, between the dissolved CH_3Cl gas and the dissolved $Ca(OH)_2$, consequently in order to get the maximum reaction velocity the solution must be kept saturated with the CH_3Cl and $Ca(OH)_2$.

"(2) That the methyl chloride be forced into the reaction vessel at such a rate that the total pressure as registered by the gage of the reaction vessel shall be maintained at a point which is considerably above the vapor pressure of the liquid alone in the absence of methyl chloride. The difference between the total pressure as registered by the gage of the reaction vessel during reaction, and that observed when there is no methyl chloride present, I designate as the effective pressure of the methyl chloride.

"I have found that the rapidity of the reaction, other things being equal, is in direct proportion to the effective pressure of the methyl chloride.

"(3) The temperature should be considerably above 100 deg. C., as the velocity—other things being equal—increases rapidly with the temperature.

The patent is assigned to the Roessler & Hasslacher Chemical Co. of New York. (1,253,055, Jan. 8, 1918.)

Purification of Crude Benzol.—HERMAN B. KIPPER of Muskegon, Mich., proposes to purify crude benzol or light oil by treating it with a caustic soda solution which contains comminuted wood-paper pulp, or other cellulose. The hydrogen sulphide is removed and the carbon bisulphide is also almost completely removed. This is explained probably by the fact that in the manufacture of artificial silk, cellulose fiber, caustic soda and carbon bisulphide react to form the so-called "xanthates," the reaction, according to Cross and Bevan, being as follows:

$$XONa + CS_2 = C\begin{matrix}SOX\\SNa\end{matrix}$$

(X representing the cellulose molecule.)

In carrying out the process, the purifying solution composed of caustic soda and the comminuted wood-paper pulp, or other cellulose, is caused to enter the top of a vessel, and the impure benzol or light oil enters the bottom of the vessel. Owing to the lighter specific gravity of the benzol or light oil as compared with the purifying solution, the benzol or light oil flows upwardly in the vessel while the purifying solution descends, and the benzol or light oil, in passing up through perforated plates, is subdivided into small drops or globules, thereby facilitating the action of the purifying solution. In consequence, the purifying solution rapidly absorbs the carbon bisulphide contained in the benzol or light oil. (1,253,048, Jan. 8, 1918.)

Purification of Potassium Chloride.—A. B. COX of Cherry Valley, N. Y., patents a process for the purification of potassium chloride which is already partly refined. The patent is assigned to the General Reduction Gas and By-Products Company of New York. Commercial potassium chloride obtained from alkali cakes may contain small amounts of sodium carbonate, borax, sodium sulphate, and also sodium chloride, which it is desirable to remove. It is proposed to add calcium chloride or a similar substance to the impure potassium chloride solution, whereby insoluble compounds are formed, except with the sodium and potassium chlorides. Fractional crystallization is then resorted to to remove the calcium chloride, the sodium and potassium chlorides remaining. One proportion of the sodium chloride is usually very small, and may be left in, or further fractional crystallization may be resorted to. (1,252,784, Jan. 8, 1918.)

United Engineering Society Officers.—The following officers were elected for the ensuing year at the annual meeting of the Trustees of the United Engineering Society, held Jan. 24, 1918: President, Charles F. Rand, Member Am. Inst. Mining Engineers; first vice-president, Calvert Townley, Member Am. Inst. E. E.; second vice-president, Robert M. Dixon, Member Am. Soc. M. E.; treasurer, Dr. Joseph Struthers, Member Am. Inst. Mining Engs.; secretary, Alfred D. Flinn, Member Am. Soc. C. E.; chairman Finance Committee, J. Vipond Davies, Member Am. Soc. C. E.

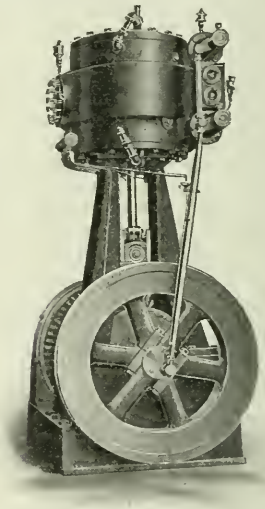
A New Vertical Rotative Dry-Vacuum Pump

A new vertical type of dry-vacuum pump is being manufactured by the Wheeler Condenser & Engineering Company of Carteret, N. J.

The pump shown was recently shipped by the manufacturers for installation in an American navy vessel.

Where much condensing is to be done and where high vacuum is to be maintained, the company recommends installing separate condensate and air pumps. Thus a motor or turbine-driven centrifugal hot-well pump can easily take care of the condensate while this Wheeler dry-vacuum air pump withdraws the air.

As the photograph shows, the inlet valves of this pump are of the semi-rotative type, which are so manipulated by the valve gear as to draw air from the condenser during its full stroke. Clearance difficulties are eliminated in this design of valve gear by providing



GENERAL VIEW OF DRY VACUUM PUMP

ports which register with an equalizing passage. The discharge valves are of the poppet type and are easily accessible, as are the other parts.

The makers state that a motor-driven dry-vacuum pump has numerous other advantages over direct steam drive, among which are: ease of installation; less attention required; no steam pipe radiation losses, and improvement of plant load factor. A few years ago it was argued that motor drive was poor practice because of the long train of elements through which power must pass before reaching the motor—the engine, generator, transmission lines, switchboard, etc.—but to-day shut-down troubles have practically vanished and authorities are strongly recommending motor-driven auxiliaries such as this dry-vacuum pump.

New Officers of American Chemical Society.—President, William H. Nichols, Jan. 1, 1918, to Dec. 31, 1918; directors: H. E. Barnard and George D. Rosengarten, Jan. 1, 1918, to Dec. 31, 1920; councilors-at-large, H. E. Howe, G. A. Hulett, W. A. Noyes, Allen Rogers, Jan. 1, 1918, to Dec. 31, 1920.

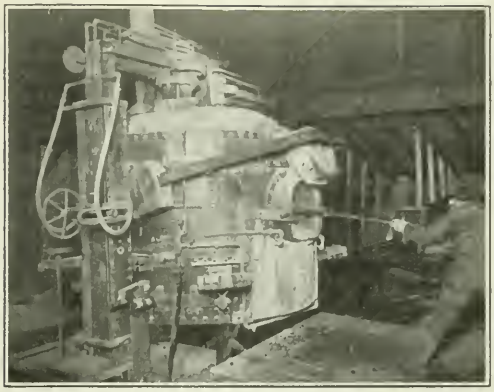
A New Electric Steel Furnace

THE Booth-Hall electric steel furnace shown in the accompanying illustrations was recently placed in operation in the plant of the Midland Electric Steel Company, Terre Haute, Ind. The furnace has a holding capacity of three to five net tons and is supplied by two single-phase transformers of 600 kva. capacity each. The transformers are Scott-connected to the 13,200-volt, 60-cycle, three-phase power line, and deliver current to the furnace at 125 volts secondary. The Scott connection gives a load well balanced over the three-phase primary circuit, as is evidenced by the meter readings. A special switch is provided for cutting the voltage in half when refining or holding heats. The electrodes are automomatically regulated and, by proper manipulation of the electrode regulators and the voltage reduction switch it is possible to put any fraction of full power into the furnace. The furnace operates at about 90 per cent power factor, giving a power input at full load of from 1000 to 1100 kw.

This furnace is built for use on either single, two or three-phase power lines and the furnace itself is built to operate either single, two or three-phase. The single-phase furnace employs an auxiliary electrode, a main electrode, a conducting hearth and a cast-steel grid buried under the hearth. The two-phase furnace employs two main electrodes and two grids, whereas the three-phase furnace employs three main electrodes but only one grid. It is anticipated that the furnace for single-phase operation will be built only in the smaller sizes, as a single-phase load of any considerable size is not acceptable to power companies. Three-phase operation will be employed only in the largest capacities where the increased number of electrodes will tend to facilitate melting down and refining. The two-phase furnace will be suitable under most conditions, and it is with such a furnace that this article deals.

Scrap steel, ranging from machine shop turnings to heavy melting steel, is charged into the furnace. When the furnace is charged the auxiliary electrode and the two main electrodes are let down until they rest upon the scrap. A pawl upon the auxiliary electrode holder is released so that the electrode rests of its own weight upon the scrap and the main electrodes are drawn up, creating an arc under each, the arc being governed by the automatic electrode regulators, assuring a uniform power imput into the furnace and a nicely balanced load in the power lines. This results in heat being generated by the two arcs from the main electrodes to the scrap, while the auxiliary electrode, under which no arc is formed, acts as the common return. By reason of the electrode resting of its own weight upon the scrap, no arc can form under the auxiliary.

When a pool has been formed on the hearth sufficient to make it conductive of electricity, the current begins to flow through the hearth and out through two sets of steel grids embedded beneath the hearth. The fact that this is taking place is immediately recorded by the ammeters, and the auxiliary electrode is then drawn out of contact with the scrap and forms its own seal of the electrode opening in the roof. The furnace then continues to operate as a two-phase



GENERAL VIEW OF BOOTH-HALL FURNACE

furnace, with two independent circuits, the current from one side of each transformer making a complete circuit through one electrode, across the arc, through the bath and the hearth to the opposing grid, and so back to the other side of the transformer.

It is to be noted that the auxiliary electrode is withdrawn before the scrap underneath melts and consequently no carbon is absorbed by the liquid steel from this source.

The advantages claimed for this principle of operation are:

(1) The use of the auxiliary electrode renders the starting of every heat positive and does away with trouble in making contact.

(2) The use of the conducting hearth gives uniform heating of the entire bath, prevents sculls and makes speedier and more thorough distribution of the heavier alloys, such as chrome, tungsten, vanadium, manganese and nickel, which sink to the bottom of the bath.

(3) The use of two independent circuits, crisscrossing in the bath, combined with bottom heating, gives a maximum circulation of the bath.

(4) The use of an auxiliary electrode in combination with a conducting hearth enables the use of a minimum number of electrodes for multi-phase service, since the auxiliary electrode is used only at the very beginning of the heat when conditions are least severe. This results in lower electrode consumption and reduction in heat losses.

(5) The hearth is solid, similar to the open hearth, with no openings or bottom contact to weaken the lining, and is sintered in place, layer by layer, forming a monolithic mass. There is no water-cooling of hearth or grids, and the operation of the furnace has shown that none is necessary.

On an absolutely cold botton it is necessary to employ the auxiliary electrode for about 45 min. before the hearth becomes conductive of electricity. On a furnace that has been shut down over night it requires from 20 to 30 min., and on a hot furnace not more than 10 min. and frequently not at all.

The Booth-Hall furnace is spherical in shape with a saucer-like bottom. The shell is made of ½-in. riveted steel plate. The main electrodes are placed on opposite sides of the furnace and the auxiliary electrode directly alongside of one of the main electrodes and toward the front of the furnace.

The furnace may be lined either basic or acid, the unit at Terre Haute being lined basic. The hearth is 24 in. thick and the grids are 18 in. below the top of

the hearth. The furnace hearth is composed chiefly of either magnesite or dolomite and is solidly sintered in, layer on layer. From the hearth up the walls are made of brick, the first three rows which reach above the slag line being made of magnesite brick and the rest of silica brick. Silica brick are employed for the roof.

The furnace door is of improved design, consisting of a door with open back to which is attached two yokes, each counter-weighted. The yokes extend part way from the door toward the sides of the furnace and by reason of the counter-weights the door can be raised with one hand by the furnace operator. The door is built in with brick, the open back allowing radiation of the heat and preserving the brick. The door pivots on the yokes as it is raised and lowered, keeping the hot inner side always to the furnace wall. The door is oval in shape so that there is no tendency to breast up the opening, as is done where round doors are employed and there is, therefore, maximum charging space. It is possible to raise the door as far as

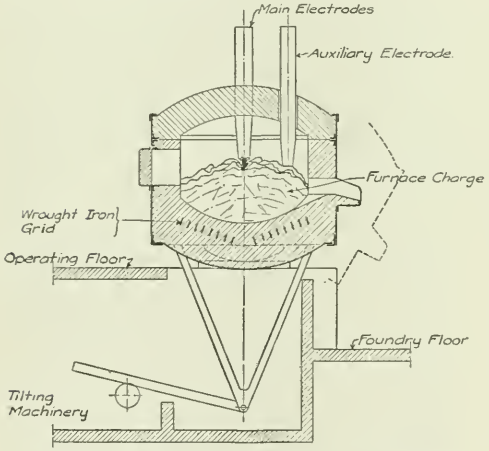


FIG. 1. DIAGRAMMATIC LAY-OUT OF TWO-PHASE FURNACE

required so that for looking into the furnace for rabbling or for taking out test ladles, the entire opening does not have to be employed. The door comes down flush against the door frame, preventing heat losses from the furnace and also the seeping of air into the furnace to disturb the furnace conditions. The door frame is made in two sections, one of which extends across the top and can be readily replaced when burnt out.

By placing the door in the rear of the furnace changing and slagging operations are simplified. By tilting the furnace forward it is possible to change the furnace quickly by the use of a hopper arrangement similar to that used for charging concrete mixers. By tilting the furnace backward it is possible to bring the slag flush with the door sill, either for rabbling or for pouring it off into slag pots. It is also practical to pour fluid slags over the charging spout.

The furnace is tilted by a very simple arrangement of rockers, structural steel struts and reducing gears. The rockers are placed under the furnace in such a way that there is no possibility of material falling on the guides and interfering with the tilt. The furnace tilts backward as well as forward, so that it is possible to bring the slag line flush with the door when slagging from the furnace, making slagging a speedier operation and easier on the furnace men.

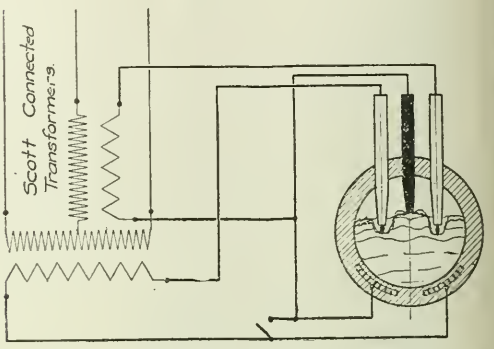


FIG. 2. ELECTRICAL CONNECTIONS FOR TWO-PHASE FURNACE

The electrode clamps are of an improved construction which allows of clamping or releasing the electrode by turning a lever at the edge of the furnace and does away with necessity of the operator climbing on the furnace roof. Each segment of the electrode clamp is water-cooled. The electrode holders are of rugged construction, each being capable of holding 10 tons at the end. Magnetic circuits are broken up by a special construction.

It will be noted in the accompanying illustrations that no electrode water cooling collars are shown in the roof, due to the fact that the temporary arrangement of three electrodes in each holder is used, and it has been found difficult to make a practical collar under the circumstances. The design of the furnace calls for a special type of electrode collar, which fits

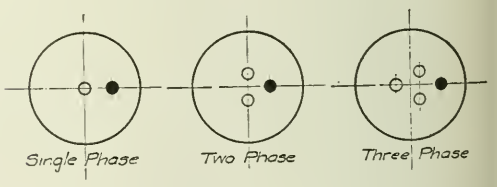


FIG. 3. RELATIVE LOCATION OF MAIN AND AUXILIARY ELECTRODES IN SINGLE, TWO AND THREE-PHASE FURNACES

around each electrode, extending well down into the roof brick, providing further protection for both the electrodes and the roof arch at this point. Differing from other types of electric furnaces, the Booth-Hall has provided not only water-cooling collars around the electrodes, but water-cooling in the electrode clamps themselves.

The Booth-Hall electric steel furnace was originated by William K. Booth, and its mechanical design carried out by Julius R. Hall. The furnace is manufactured by the Booth-Hall Company, Chicago, Ill.

Book Reviews

COAL TAR AND AMMONIA. By *George Lunge, Ph.D.* Fifth and enlarged edition. 1658 pages. Price, $18. New York: D. Van Nostrand Company.

No book could come more opportunely at this time than this most comprehensive compilation of information regarding the most vital subjects of coal tar and ammonia.

With true European thoroughness every possible scrap of information relative to these matters has been brought together, often it seems without a sufficient amount of discrimination.

Processes and patents that have never even got beyond the paper stage are placed side by side with those that are the foundations for world industries, thus making it hard for the non-expert to discriminate with intelligence.

The first two volumes discuss at length and in considerable details not only the different methods of obtaining coal tar, but also the fractionation of the different constituents and the products obtainable from these.

The third volume discusses ammonia, and should be carefully studied by all those who to-day advocate the installation of a government nitrogen fixation plant.

The many means by which ammonia can be obtained from various waste products now going to waste in the United States is made apparent even by a cursory glancing through this volume.

The references occurring all through the three volumes are up to the very latest date.

It really goes without saying that these last volumes by Dr. Lunge are standard and are another monument erected by him to applied chemistry.

* * *

FINDING AND STOPPING WASTE IN MODERN BOILER ROOMS. By *Engineers of the Harrison Safety Boiler Works.* Cloth, 9 in. by 7 in., 276 pages, 213 illustrations. Price, $1.00. Philadelphia: Harrison Safety Boiler Works.

The saving of coal is the purpose of this handbook, which is addressed to power plant owners, managers, engineers and firemen. The preface states that such statements, tables, charts, etc., have been selected as were supported by experiments and tests, references being given wherever possible to the original authorities. The book is divided into five sections under the following headings: Fuels, Combustion, Heat Absorption, Boiler Efficiency and Boiler Testing, Boiler Plant Proportioning and Management. It is illustrated and conveniently indexed and discusses theory and practice under each heading. The compilation was made by George H. Gibson, assisted by Percy S. Lyon, now a captain in the Coast Artillery. The book contains a large amount of very useful information for anyone connected with or interested in power plant work.

* * *

TESTING FOR THE FLOTATION PROCESS. By *A. W. Fahrenwald.* Pocket size, 4 in. by 7 in., 173 pages, 34 illus. Price, $1.50. New York: John Wiley & Sons, Inc. London: Chapman & Hall.

This work is a compendium in handy form of a variety of data and information that will be useful to the metallurgist. The author has not introduced many personal ideas, but has drawn widely and freely on excellent sources of information. In this respect the book represents a condensation of the best literature, with references enabling anyone to pursue the subject further. In order to make tests intelligently it is necessary to understand fundamental principles. Hence the greater part of the book is devoted to a discussion of the physics and chemistry of flotation and the materials used in the process. The subject of colloids is clarified and condensed sufficiently to give the reader a sound idea of its relation to flotation. In like manner surface tension, capillarity, osmosis, viscosity and emulsification are discussed. Oils, addition agents and the use of sulphidizing agents receive ample consideration. When all these subjects are covered, the author devotes a chapter to tests, and discusses the effect of method of grinding, fineness of grinding, kind and amount of frothing agent used, temperature, acidity or alkalinity, varying speed of agitation and effect of addition agents. A chapter on appropriate formulas and tables completes the book.

* * *

THE LIFE OF ROBERT HARE, AN AMERICAN CHEMIST. By *Edgar Fahs Smith.* 508 pages. Price, $5.00. Philadelphia: J. B. Lippincott & Co.

The Provost of the University of Pennsylvania, better known to chemists as Prof. Edgar Fahs Smith, has made a distinct contribution to the history of modern science in this beautiful volume. Robert Hare lived in Philadelphia at a time when, as Dr. Smith says, science flourished as nowhere in America. He was born in 1781. Benjamin Franklin was still living, Joseph Priestley came later from England, James Woodhouse, fresh from the inspiration of Lavoisier, was his teacher and adviser, and these were also the days of Sir Humphrey Davy and Volta and Berzelius. With Faraday he had a long correspondence. There were giants in those days.

The Life is divided into three periods, of which the first was from his birth to 1818, or until he was thirty-seven years old. This covers the time of his study at the University of Pennsylvania, the beginning of his life-long friendship with Benjamin Silliman, and the period of his activity as a business man, during which time he never ceased to work in his private laboratory and to address himself to the study of science. His father, an Englishman by birth, who achieved prosperity by brewing porter, gave his son a sound classical education, and throughout his abundant years we find constant indications of his native and cordial familiarity with the graces of life. He succeeded his father in the administration of the affairs of Hare's brewery until near the close of the first period. In 1816 he received an honorary doctorate of medicine from Harvard College, and in 1818 he was appointed to the chair of chemistry at the school of medicine of the University of Pennsylvania. This he filled with great usefulness and distinction until his voluntary retirement in 1847, when the trustees conferred upon him the title of Professor Emeritus. He died in 1857.

He discovered the oxy-hydrogen blow-pipe. This is distinctly his invention, which he developed as a young man, shortly after leaving the University. With it he was able to melt platinum, and years afterward one of his pupils, J. Bishop, founded the platinum industry at Malvern, Pennsylvania. Another application of his discovery was the limelight, the Drummond light, so called, which gave the first powerful illumination for lighthouses. As early as 1822 he used a cathode of mercury in an aqueous electrolyte, and then and there was born the idea which led to the production of caustic soda from salt by the use of a mercury cathode in our own time. Not long afterward he brought out Hare's deflagrator, which was, in fact, a mobilized voltaic pile. Powerful deflagrators were in common use in America long before any apparatus of equal efficiency was known in Europe. Faraday declared it to be the most perfect form of the apparatus then known, and he acknowledged Hare as the inventor, although he had, at a later date, devised a voltaic trough to meet his needs that was the same in principle. Hare's calorimeter was another contribution. He originated important steps in gas analysis and he was a pioneer in the development of endometers. In 1839 he devised an actual electric furnace in which he isolated calcium, prepared calcium carbide which gave him acetylene (but which he did not recognize), and converted amorphous carbon into graphite. It was all primitive and crude, but here is the record! These are but a fraction of his contributions.

It is a book that should be in the library of every chemist who is of scholarly disposition. Correspondence, especially with Professor Silliman, fills a large part of the volume, and it is not always easy reading, because the literary habits of men of science have changed. He did not make drawings of his apparatus, he described them, and we are so accustomed to getting our ideas from drawings and so unused to descriptions without drawings to help us that the tax upon the memory while reading is unwonted and so seems severe. His language, nevertheless, was de-

lightful, and while he was a bit disputatious, it was always because of his convictions and his earnest effort to approach the truth. He was not satisfied with the distinctions between acids and bases as taught, and his views, which are presented at length, are of marked interest. He was a careful and exact thinker and a reading of this book leads to the conclusion that the progress of chemistry would have been helped by a livelier memory of the contributions of Robert Hare. We felicitate Professor Smith on his accomplishment and are thankful for the record.

* * *

SULPHURIC ACID AND ALKALI. By *George Lunge, Ph.D.* Supplement to Vol. I, Sulphuric and Nitric Acid, 4th Ed. Octavo (14 x 22 cm.), 347 pages, 25 cuts. Price, $5.00 net. New York: D. Van Nostrand Company.

Intended to supplement the 1913 edition by adding a complete record of all subsequent improvements in the art, and incidentally to save the purchasers of the 1913 books from having to buy an entirely new edition in order to get this recent literature. It looks as if the final solution might be found in resolving the treatise into a "Yahrbuch," thus bringing everyone interested up to date annually. The index includes both the subject matter of the original Volume I and of this supplement. The chapters correspond to those of the original volume, and each article is referred to the page where it fits into the earlier text. An immense amount of valuable literature is thus made available and accessible. The only criticism we have to offer is that many visionary statements and patent claims are reproduced without comment, giving to the book, in places, the character of a mere compilation rather than a treatise wherein the author is guide and mentor.

Personal

Mr. ROBERT J. ANDERSON, late chief chemist for the Cleveland Metal Products Co. is now engineer of tests of ordnance material, War Department, and is stationed at the Brier Hill Steel Co., Youngstown, Ohio.

The partnership of Falkenburg & Laucks, of Seattle, Wash., has been dissolved effective Feb 10, 1918. Mr. M. J. FALKENBURG has organized a company to be known as Falkenburg & Co., analytical and consulting chemists, Second and Yesler Sts., Seattle, Wash. Mr. I. F. LAUCKS has also established a separate business as chemist and metallurgist at 99 Marion St., Seattle.

Mr. RUSSELL T. GRAY, formerly advertising manager of the Haynes Automobile Company and more recently secretary of the Shuman Advertising Company, has opened an office in the First National Bank Building, Chicago, as an advertising engineer in the technical field.

Mr. ELLWOOD HENDRICK of New York City has allied himself with the staff of METALLURGICAL AND CHEMICAL ENGINEERING as Consulting Editor. For some time past Mr. Hendrick has been an occasional editorial contributor to this journal, and his intimate familiarity with phases of our rapidly growing chemical industry will assist us materially in reflecting conditions in that important branch of the field to which our pages are devoted.

Mr. A. G. MCGREGOR, who erected the International, Calumet & Arizona, Verde Extension and other reduction works in the Southwest, has returned to Arizona from New York and is expected to sail at an early date for Chile and Peru with representatives of copper interests.

Mr. WILLIAM PIGGOTT of Seattle, Wash., president of the Seattle Car & Foundry Co., and vice-president of the Pacific Coast Steel Co., has been placed in charge of wooden shipbuilding for the United States Shipping Board in the Seattle district. Mr. Piggott will succeed Capt. J. F. Blaine, who will retain charge of the steel ship construction.

Dr. CHARLES L. REESE, Chemical Director of the E. I. du Pont de Nemours Co., has been elected chairman of the Philadelphia Section of the American Chemical Society. Dr. Reese was recently elected a director of the du Pont Company.

Mr. S. S. SADTLER of Philadelphia was in New York on business during the first week of February.

Mr. WILLIAM WRAITH, general manager of the International Smelting Company has gone from Salt Lake City to New York to assume additional duties as vice-president of the Andes Copper Mining Co. Mr. Wraith expects shortly to make a trip to South America in connection with plans for development of their low-grade copper deposits at Porterillas, Chile. O. M. KUCHS, since 1913 superintendent of the Tooele smelter of the International Smelting Co., has assumed the position of assistant general manager with headquarters in Salt Lake City, while A. B. YOUNG, superintendent of the blast furnace department has been made superintendent of the smelting plant.

Current Market Reports

The Iron and Steel Market

The iron and steel industry has felt practically no results from Fuel Adiminstrator Garfield's fuel conservation order. There has been practically no ultimate loss of production, as the blast furnaces were permitted to operate and any pig iron accumulated can either be used in steel production or be set aside as a convenient reserve. Transportation conditions have not been improved, but it is conceded in most quarters that had it not been for the fuel order they would have become still worse.

PRODUCTION LIGHTER

Blast furnace operations have been still lighter, the past two or three weeks seeing the smallest production of pig iron in this whole period of restricted operations. Apart from the general railroad blockade there have been particularly bad weather conditions in the Connellsville coke region, and not only have coke receipts at furnaces been very light, but pig iron production in proportion to coke has been particularly light. Many furnaces, through frequent bankings, have been showing a coke consumption of 2800 to 3000 lb. per ton of pig iron. Many furnace managers are making a careful effort to anticipate coke supplies and operate their furnaces with correspondingly light blasts, so as to insure regular and continuous operation, no matter how light the output. One furnace manager claims to have operated for a considerable period with an output 50 per cent of normal, yet with a coke consumption of only 2400 lb.

The blast furnaces of the Central West depending upon Connellsville coke have been producing an average of 25 to 40 per cent of their capacity in pig iron. Blast furnaces depending upon by-product coke have done much better, possibly 75 per cent. The difference is not in transportation conditions in general, but that the Government favors the movement of by-product coal, not on account of the coke it produces, but on account of the by-products. In other words the real condition is that the coke is the by-product and the toluol, etc., the product. One recalls the time when the first Gary blast furnaces were put in operation, not so much for the purpose of supplying pig iron as for the purpose of supplying gas for the first run of the steel department. The pig iron could be secured elsewhere, the gas could not.

While the supply of pig iron is thus very much restricted, the ability of mills to ship finished steel is at least equally restricted, and it is a question whether steel mill operations as a while are being limited the more by shortage of raw material or inability to dispose of finished product. There is practically no storage capacity left in mill warehouses or yards, and production in nearly all finishing departments is regulated by car supplies and permits to ship. Unfortunately these two necessary elements are not always synchronous. One may load steel and wait for a permit, paying demurrage meanwhile, or seek a permit first and then see its time limit pass while one is waiting for cars.

Shipments of finished steel products from mills in the past fortnight have averaged somewhat less than 60 per cent of capacity. This means more than 60 per cent of the output in 1916, as while the mills operated full in that year, the capacity at present is much larger, by between 10 and 15 per cent. Fully two-thirds of the shipments have been of war steel, leaving commercial shipments at not more

than 20 per cent of capacity. Not all war steel on order is possible of shipment, however, there being various restrictions in that quarter also.

Despite the fact that steel receipts by ordinary commercial consumers are only about 20 per cent of the productive capacity, there is no particular complaint, as to shipments, on the part of buyers. There operations are equally restricted by the transportation situation.

The Outlook

The iron and steel industry has nothing but an outlook. There has been no market for weeks past, and there will be no regular market until the transportation situation has been loosened up and the business of making and consuming steel, at something like a normal rate, can be resumed. Presumably the backbone of winter has been broken, and the common view in the trade is that the effectiveness of the railroads is going to be greatly increased by the advent of respectable weather, the chief menace now being that of floods. The congestion may clear rapidly, but in all probability the clearing will be sporadic geographically, and that may introduce fresh complications. That the steel industry will follow closely upon the heels of the railroads is certain. As transportation conditions improve steel production will at once increase.

There is very little attempt to speculate what will be done or will not be done at Washington against the date, March 31, to which the set prices were continued by the President's announcement late in December. A great deal can occur, as to consumption and production, before that time. The question of costs, so much discussed in the late months of last year, is a dead issue. There are no costs, according to the common view of costs. There is simply a total of expenses, made up in altogether unusual manner, and a total of tons that chanced to be shipped. Dividing the one by the other means nothing as to next week or next month.

The Navy Department's experiment of inviting competitive bidding on the purchase of a variety of steel products is an interesting departure. Hitherto the placing of orders has been in the form of allotments, the set prices being taken as a matter of course. The competition has resulted in some prices being made, chiefly for manufactured steel such as rivets, nuts and bolts, etc., at materially lower than the set prices. Doubtless Washington will be disposed to carry the experiments farther. As a buyer the Government has an advantage at the moment it does not ordinarily enjoy. Government red tape is as objectionable as formerly, but there is the great distinction that if one has a Government order his chances of being able to ship the material are very much greater than if the order is for ordinary commercial steel.

Thus the main outlook the iron and steel market has at this writing is that within the next few weeks there are likely to be physical and other developments of fundamental importance, that will furnish a basis on which the future of tonnage and prices can be considered.

Non-Ferrous Metal Market

Friday, Feb. 8.—Conditions are unchanged in the copper market with inactivity prevailing. Tin is just as scarce and is higher. Lead is dull but remains firm. Spelter is still dull and somewhat unsettled.

Tin—Supplies of spot tin of any size are hard to locate and no Straits tin is offered for sale. Arrivals in January were less than 2000 tons, and so far this month 175 tons have arrived with 5350 tons reported afloat from the Straits. *The American Metal Market* says: "The combination of a further advance abroad, heavy inquiry here, and the non-receipt of private offers have caused an extremely strong market and there is greater irregularity than ever between different sellers' prices, some having practically withdrawn from the market in anticipation of further advances.

"Some values in various positions are approximately as follows:

"Ninety-nine per cent quality for delivery in a week or so at 78c. per pound.

"Banca tin on steamer actually afloat at 73.50c.

"Banca tin February shipment from Batavia at 70c.

"Banca tin March shipment from Batavia at 69.50c."

Copper—Better weather conditions are expected to relieve the transportation situation and to afford relief in the way of supplies of matte and blister copper for the Eastern refineries. The market is comparatively dull and unchanged at the Government price of 23.50c. for producers and 24.67½c. for jobbers.

Lead—The trust price in New York remains at 6.75 with outsiders asking 7c. as a minimum. The St. Louis market is around 6.80c. Supplies are not large, owing to the railroad congestion, but better weather is expected to afford relief.

Spelter—The market continues quiet. No price has yet been fixed for Grade A, although numerous rumors were around that 12c. had been agreed upon. Prime Western is held at 8c., New York and 7.75c. at St. Louis.

Tungsten—Scheelite is offered at $30 by California producers but no sales are reported at that figure. Importers report the nominal price of $26 for scheelite and $20 to $26 for wolframite. Tungsten, molybdenum, vanadium, manganese, chrome and ferro-alloys come under the license authority of the American Iron and Steel Institute in so far as these ores are imported from abroad. Importer dealers and consumers are henceforth required to give a guarantee before shipments are released to them.

Molybdenum—Charles Hardy reports considerable activity in molybdenite at $2.15, basis 85 per cent. Arrivals in the East have lately increased but have been readily absorbed.

Quicksilver—California virgin is quoted at $130 with Mexican at $120.

Chrome—Ore is still scarce and higher.

Other Metals

Aluminium, lb.	.36–.38
Bismuth, lb.	2.50–2.75
Cadmium, lb.	1.50
Nickel, electrolytic, lb.	.55
Silver, oz.	.86⅛
Platinum, oz.	105.00
Palladium, oz.	130.00–135.00
Cobalt, lb.	3.25–3.50
Magnesium, lb.	2.00

Chemical Market

Coal-Tar Products: Quiet prevailed in this situation during the interval. Transit conditions, as well as the inability of plants to secure sufficient coal to operate up to regular schedule, tends to restrict operations. With the government taking over several of the important items the trade is evidently delayed in acclimating itself to the new conditions created.

Benzol: While there are more contracts being closed over the next few months than for some time heretofore, there are not many contracts being closed over the entire year. Spot supplies are plentiful and prices are low.

Phenol: There is but little material offered at this time. The government has contracted for practically all the material to be produced for some time to come.

Toluol: Several dealers have succeeded in securing material which has been selling at fancy prices, but the government is following up the matter and has seized several lots in the past few days.

Naphthalene is not active. Both buyers and sellers appear to be giving the matter but little attention. Prices are unchanged.

Aniline Oil has been advanced in price because of the scarcity and high prices of the necessary acids.

Aniline Salt is fairly firm with low offerings absorbed and producers quoting an advance of a cent or two.

Dimethylaniline: The demand is quiet, but offerings are light and prices are fairly well maintained.

Diethylaniline: There are but few producers of this material and offerings are so light that quotations are nominal.

Diphenylamine: This material is in heavy demand by explosive manufacturers, and there is practically none available in the open market.

Benzoate of Soda is held in speculative hands, with producers sold up and prices fluctuating over a wide range.

Saccharine. Surplus quantities are flooding the market because of the falling off in the export demand, and prices have been reduced by more than 50 per cent.

Salicylic Acid: With a heavy output and only a routine demand a break in price has resulted.

Para Nitro Phenol: The production is restricted to a few quarters ; the demand is fair and prices are well maintained.

HEAVY CHEMICALS.—As a result of the freight embargoes and the order of the fuel administration there has been a gradual readjustment of chemical values. Buyers, owing to the uncertainty of deliveries, have not shown any particular desire to purchase for shipment from works. There has however been a gradual improvement in the demand for spot lots and for material at near-by shipping points, and these offers have generally commanded a premium. As a result of greatly restricted shipment during January bills of lading of that month are in particular demand in order to carry out contracts to the letter.

Caustic Soda: From a product highly speculative the movement in caustic has been of such minor consequence that many items other than this have shown more activity. During the early weeks of January there was practically no activity noted. As the movement closed it was apparent that January shipments from works were very meager, and those who had sold actual January shipment now find a market of approximately 6.40 for these bills as against 5.45 for February shipment. For shipment, March sales have occurred at 5.35, but this price is low. Producers are not inclined to go much below 5.50 for any position up to June.

Soda Ash: There has been a very urgent request for prompt ash in barrels, and it is apparent export permits have been granted for important amounts. Barrels have sold as high as 3.45, and at the moment there is practically no material available in New York in this package. Bags have not been in such urgent request, and the market remains at about 3c. for spot and from works. Dense ash continues scarce and single bags are held at 3.85 barrels and double bags at 4c.

Sulphuric Acid: Considerable acid has appeared on the market during the interval, not due to any increased output but to the fact that acid has backed up on producers, who have found it difficult to ship in face of the embargoes. Tank cars are so scarce that much acid that would be otherwise bought remains at producing point owing to lack of carrying room. Sixty-six-degree acid has been available at prices ranging from $38 to $42, seller's tanks, works. For export there has been considerable business passing in drums at $90 f.a.s., drums included. Sixty-degree acid has been offered at $32.50 works, seller's tanks.

Muriatic Acid: The product continues scarce. Practically no test other than 20 is offered. Weak acid does not attract a buyer, and in view of the high prices obtained for the 20-deg. manufacturers see no profit in concentrating to 22 deg. Contracts have been offered of 20 deg. at 2.50 to 2.65 works, car quantities.

Nitric Acid: Off-colored material has been available at 9c., but pure white acid 42 deg. is held at 9½ to 10c. works.

Cyanide of Soda: There has been more activity noted and prompt material has sold at 43½c., although at the moment of writing there are lots available at 42c.

Copper Sulphate: Both Nichols and A. S. & R. brands have been offered by second hands at prices ranging from 8.70 to 9c. Sales have occurred in fairly large quantities at 8⅞c., and the second-hand market has been fairly well cleaned up. Nine cents is now a good price from second hands. Producers are quoting 9½c. All prices are for 99 per cent large crystals, prompt shipment.

Bichromates: The spot market has again developed into a speculative one, and there is again evidence of manipulation. Spot lots have generally commanded considerable attention and sales have occurred at from 20c. to 24c. From works sellers quote 22c. to 24c. and even higher for late deliveries. The potash material has been neglected and there have been actual offers at 41c.

Chlorate of Potash: The American producers have seemingly gone after the Japanese producers with a big stock. Although for domestic consumption 40c. to 42½c. are the lowest prices obtainable for export, 35c. and 36c. have been named with the broad intimation that even lower prices would be considered if necessary. For domestic business a resale occurred at 36c., but aside from this there does not appear to have been much business undr 40c. Japanese material has sold at 35c. and 36c. rolling to New York

Sodium Sulphite: Prompt stocks have been about eliminated from the market. For March shipment there are sellers of the 99/50 per cent moisture at 5c., New York.

Sodium Sulphide: Spot values have advanced to 5c for the 60/62 per cent fused. From works sellers quote 4¾c. to 4⅞c.

Hydrosulphite of Soda: There are offers of the powdered at $1.45 and a 10 per cent liquid is offered at 6½c.

Hyposulphite of Soda: Spot lots have changed hands at 2½c., and contracts are available at 2c. works for tanners' size. Pea size is held at approximately ½c. higher.

Prussiates: The sodium salt has been very scarce, and spot values have advanced to 37½. The yellow potassium salt has been somewhat easier and there are supplies available at $1.22½.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, FEB. 7, 1918

Acetic anhydride	lb.	1.35 — 1.50
Acetone, drums	lb.	Nominal
Acid, acetic, 28 per cent	lb.	.05½— .06
Acetic, 56 per cent	lb.	.11¼— .12
Acetic, glacial, 99½ per cent, carboys	lb.	.34 — .35
Boric, crystals	lb.	.13¼— .14¼
Citric, crystals	lb.	.75 — .78
Hydrochloric, C. P	lb.	Nominal
Hydrochloric, 20 deg	lb.	.02½— .03
Hydrochloric, conc., 22 deg	lb.	.03 — .03½
Hydrofluoric, 30 per cent, in barrels	lb.	.06 — .06½
Lactic, 44 per cent	lb.	.15 — .15½
Lactic, 22 per cent	lb.	.05½— .06½
Nitric, 36 deg	lb.	Nominal
Nitric, 42 deg	lb.	.09½— .09½
Oxalic, crystals	lb.	.45½— .46½
Phosphoric, 47-50 per cent crude	lb.	.07½— .08
Phosphoric, ref. 50 per cent	lb.	.26 — .....
Picric	lb.	Nominal
Pyrogallic, resublimed	lb.	3.15 — 3.25
Sulphuric, 60 deg	ton	..... — 35.00
Sulphuric, 66 deg	ton	40.00 — 45.00
Sulphuric, oleum (Fuming), tank cars	ton	75.00 — 80.00
Tannic, U. S. P., bulk	lb.	1.30 — 1.35
Tartaric, crystals	lb.	.75 — .78
Tungstic, per lb. of W	lb.	1.80 — 1.90
Alcohol, sugar cane, 188 proof	gal.	4.85 — .....
Alcohol, wood, 95 per cent	gal.	1.35 — 1.38
Alcohol, denatured, 180 proof	gal.	.69 — .70
Alum, ammonia lump	lb.	.04½— .05
Alum, chrome ammonium	lb.	.18½— .19
Alum, chrome potassium	lb.	.21 — .23
Alum, chrome sodium	lb.	.12½— .13
Alum, potash lump	lb.	.09 — .09½
Aluminium sulphate, technical	lb.	.02 — .02½
Aluminium sulphate, iron free	lb.	.03½— .04
Ammonia aqua, 26 deg. carboys	lb.	.19½— .20
Ammonia, anhydrous	lb.	.40 — .43
Ammonium carbonate	lb.	.10¾— .11
Ammonium nitrate	lb.	(Fixed price) .14
Ammonium, sulphate domestic	lb.	.07¼— .07½
Amyl acetate	gal.	5.00 — 5.25
Arsenic, white	lb.	.16¼— .16½
Arsenic, red	lb.	.65 — .70
Barium carbonate, 99 per cent	ton	80.00 — 90.00
Barium carbonate, 97-98 per cent	ton	65.00 — 67.00
Barium chloride	ton	70.00 — 90.00
Barium sulphate (Blanc Fixe, powder)	lb.	.03¾— .04
Barium nitrate	lb.	.12 — .14
Barium peroxide, basis 70 per cent	lb.	.30 — .32
Bleaching powder, 35 per cent chlorine	lb.	.02½— .02¾
Borax, crystals, sacks	lb.	.07¼— .08¼
Brimstone, crude	ton	Nominal
Bromine, technical	lb.	.75 — .....
Calcium, acetate, crude	lb.	Nominal
Calcium, carbide	lb.	.13½— .14½
Calcium chloride, 70-75 per cent, fused, lump	ton	21.00 — 22.00
Calcium peroxide	lb.	1.60 — 1.70
Calcium phosphate	lb.	.34 — .35
Calcium sulphate	lb.	..... — .....
Carbon bisulphide	lb.	.07½— .08
Carbon tetrachloride, drums	lb.	.16 — .17
Carbonyl chloride (phosgene)		..... — .....
Caustic potash, 88-92 per cent	lb.	.84½— .85
Caustic soda, 76 per cent	lb.	.05¾— .06½
Chlorine, liquid	lb.	.15 — .18
Cobalt oxide	lb.	1.40 — 1.50
Copperas	lb.	.01¼— .01½
Copper carbonate	lb.	.45 — .....
Copper cyanide	lb.	.75 — .78
Copper sulphate, 99 per cent, large crystals	lb.	.09 — .09½
Cream of tartar, crystals	lb.	.61 — .63
Epsom salt, bags	lb.	.03 — .03½
Formaldehyde, 40 per cent	lb.	.20 — .21
Glauber's salt	100 lb.	1.00 — 1.10
Glycerine, bulk, C. P	lb.	.67½— .70
Iodine, resublimed	lb.	4.25 — 4.35
Iron oxide	lb.	.13 — .15
Lead, acetate, white crystals	lb.	.17 — .17½
Lead arsenate (Paste)	lb.	.15 — .18
Lead nitrate	lb.	.15 — .16
Litharge, American	lb.	.09½— .11½
Lithium carbonate	lb.	1.50 — 2.00
Manganese dioxide, U. S. P	lb.	.70 — .75
Magnesium carbonate, technical	lb.	.09½— .10
Nickel salt, single	lb.	.14 — .15
Nickel salt, double	lb.	.12 — .14
Phosgene, see Carbonyl chloride		..... — .....
Phosphorus, red	lb.	1.35 — 1.40
Phosphorus, yellow	lb.	1.25 — .....
Potassium bichromate	lb.	.43 — .45
Potassium bromide granular	lb.	1.35 — 1.50
Potassium carbonate calcined, 85-90 per cent	lb.	.50 — .55

Potassium chlorate, crystals	lb.	.40	—	.42½
Potassium cyanide, 98-99 per cent	lb.	Nominal		
Potassium iodide	lb.	3.75	—	3.80
Potassium muriate 80-85 p. c. basis of 80 p. c.	ton	350.00	—	
Potassium nitrate	lb.	.30	—	.32
Potassium permanganate (U. S. P.)	lb.	4.00	—	4.10
Potassium prussiate, red	lb.	2.60	—	2.70
Potassium prussiate, yellow	lb.	1.25	—	1.27
Potassium sulphate, 90-95 p.c. basis 90 p.c.	ton	Nominal		
Rochelle salts	lb.	.39	—	.39½
Salammoniac, gray gran	lb.	.17	—	.17½
Salammoniac, white gran	lb.	.15	—	.16
Sal soda	100 lb.	1.25	—	1.30
Salt cake	ton	22.00	—	23.00
Silver cyanide, based on market price of silver	oz.		—	
Silver nitrate	oz.	.57	—	.58
Soda ash, 58 per cent, light, flat	100 lb.	3.00	—	3.05
Soda ash, 58 per cent, dense, flat	100 lb.	3.80	—	4.00
Sodium acetate	lb.	.16½	—	.17
Sodium bicarbonate, domestic	lb.	.02⅝	—	.03
Sodium bicarbonate, English	lb.		—	
Sodium bichromate	lb.	.22	—	.24
Sodium bisulphite, powd	lb.	.06¼	—	.06½
Sodium chlorate	lb.	.24	—	.25
Sodium cyanide	lb.	.42	—	.44
Sodium fluoride, commercial	lb.	.18½	—	
Sodium hyposulphite	lb.	.02½	—	
Sodium molybdate, per lb. of Mo	lb.	2.50	—	
Sodium nitrate, 95%	100 lb.	4.35	—	4.50
Sodium nitrite	lb.	.30	—	.35
Sodium peroxide	lb.	.45	—	.50
Sodium phosphate	lb.	.04	—	.04½
Sodium prussiate, yellow	lb.	.37½	—	.40
Sodium silicate, liquid (60 deg.)	lb.	.03½	—	.04½
Sodium sulphide, 30 per cent., crystals	lb.	.02¾	—	.03
Sodium sulphide, 60 per cent., fused	lb.	.05	—	.05½
Sodium sulphite	lb.	.05	—	.06
Strontium nitrate	lb.	.25	—	.35
Sulphur chloride, drums	lb.	.06	—	.06½
Sulphur dioxide, liquid, in cylinders	lb.	.15	—	.40
Sulphur, flowers, sublimed	100 lb.	4.05	—	4.10
Sulphur, roll	100 lb.	3.70	—	3.85
Sulphur, crude	ton	Nominal		
Tin bichloride, 50 deg.	lb.	Nominal		
Tin oxide	lb.	.75	—	.90
Zinc carbonate	lb.	.25	—	.30
Zinc chloride	lb.	.10¼	—	.11
Zinc cyanide	lb.	Nominal		
Zinc dust, 350 mesh	lb.	.17	—	.18
Zinc oxide, American process XX	lb.	.12½	—	.13
Zinc sulphate	lb.	.06	—	.07

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.35	—	.40
Benzol, 90 per cent	gal.		—	
Toluol, pure water white	gal.	Nominal		
Xylol, pure, water white	gal.	.35	—	.50
Solvent naphtha, water white	gal.	.17	—	.22
Solvent naphtha, crude, heavy	gal.	.13	—	.16
Creosote oil, 25 per cent	gal.	.33	—	.35
Dip oil, 20 per cent	gal.	.29	—	.30
Pitch, various grades	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05	—	1.10
Carbolic acid, crude, 50 per cent	lb.	.60	—	.65
Carbolic acid, crude, 25 per cent	lb.	.35	—	.38
Cresol, U. S. P.	lb.	.18	—	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00	—	1.25
Alpha naphthol, distilled	lb.	1.60	—	2.00
Alpha naphthylamine	lb.	.58	—	.60
Aniline oil, drums extra	lb.	.27	—	.28
Aniline salts	lb.	.32	—	.34
Anthracene, 80 per cent.	lb.	.50	—	.65
Benzaldehyde (f.f.c.)	lb.	4.50	—	5.50
Benzidine, base	lb.	1.75	—	1.85
Benzidine, sulphate	lb.	1.40	—	1.50
Benzoic acid U. S. P.	lb.	5.50	—	5.75
Benzoate of Soda, U. S. P.	lb.	5.00	—	5.25
Benzyl chloride	lb.	2.25	—	2.50
Beta naphthol benzoate	lb.	10.00	—	12.00
Beta naphthol, sublimed	lb.	.85	—	.90
Beta naphthylamine, sublimed	lb.	2.65	—	
Dichlor benzol	lb.	.12	—	.18
Diethylaniline	lb.	4.00	—	5.00
Dinitro benzol	lb.	.35	—	.40
Dinitrochlorbenzol	lb.	.40	—	.42
Dinitronaphthaline	lb.	.55	—	.60
Dinitrotoluol	lb.	.55	—	.60
Dinitrophenol	lb.	.50	—	.55
Dimethylaniline	lb.	.57	—	.62
Diphenylamine	lb.	.85	—	1.00
H-acid	lb.	2.25	—	2.50
Metaphenylenediamine	lb.	1.85	—	2.00
Monochlorbenzol	lb.	.19	—	.22
Naphthalene, flake	lb.	.09½	—	.09¾
Naphthalene, balls	lb.	.10½	—	.10¾
Naphthionic acid, crude	lb.	1.40	—	1.50
Naphthylamin-di-sulphonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.45	—	.50
Nitro toluol	lb.	.50	—	.55
Ortho-amidophenol	lb.		—	
Ortho-dichlor-benzol	lb.	.15	—	.18
Ortho-toluidine	lb.	1.00	—	1.20
Ortho-nitro-toluol	lb.	.75	—	1.00
Para-amidophenol, base	lb.	3.50	—	4.00
Para-amido-phenol, H. Cl.	lb.	4.00	—	5.00
Para-dichlor-benzol	lb.	.12	—	.15
Paranitraniline	lb.	1.05	—	1.15
Para-nitro-toluol	lb.	1.50	—	1.60
Paraphenyleoediamine	lb.	3.00	—	3.50
Para toluidine	lb.	2.25	—	2.50
Phthalic acid anhydride	lb.	4.50	—	5.00
Phenol, U. S. P.	lb.	.53½	—	.55
Resorcin, technical	lb.	6.00	—	7.00
Resorcin, pure	lb.	10.00	—	12.00
Salicylic acid	lb.	1.00	—	1.10
Salol	lb.	1.85	—	2.00
Sulphanilic acid, crude	lb.	.32	—	.35
Toludin	lb.	2.50	—	
Toluidine-mixture	lb.	.75	—	.85

Petroleum Oils

Crude (at the Wells)				
Pennsylvania	bbl.	3.75	—	
Corning, Ohio	bbl.	2.80	—	
Somerset, Ky	bbl.	2.55	—	
Wooster, Ohio	bbl.	2.38	—	
Indiana	bbl.	1.98	—	
Illinois	bbl.	2.12	—	
Oklahoma and Kansas	bbl.	2.00	—	
Caddo, La., light	bbl.	2.00	—	
Corsicana, Tex., light	bbl.	2.00	—	
California	bbl.	.98	—	1.32
Gulf Coast	bbl.	1.00	—	
Fuel Oil				
New York	gal.	.11	—	
Pittsburgh	gal.	.07½	—	.10
Oklahoma-Kans	bbl.	1.50	—	2.35
Texas	bbl.	1.50	—	1.75
Los Angeles	bbl.	1.52	—	
San Francisco	bbl.	1.45	—	
Gasoline (Wholesale)				
New York	gal.	.24	—	
Boston	gal.	.25	—	
Pittsburgh	gal.	.26	—	
Chicago	gal.	.21	—	
Oklahoma	gal.	.25	—	
San Francisco	gal.	.20½	—	

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.19	—	.20
Cylinder, light	gal.	.34	—	.35
Cylinder, dark	gal.	.33	—	.34
Paraffine, high viscosity	gal.	.36	—	.37
Paraffine, 903 sp. gr	gal.	.29	—	.30
Paraffine, .865 sp. gr.	gal.	.21	—	.22

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f.o.b. Florida	gal.	.44	—	
Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.53	—	
Pine oil, destructively distilled	gal.	.49	—	.53
Pine-tar oil, sp. gr., 1.025-1.035	gal.	.35	—	
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.40	—	
Pine oil, light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—	
Pine oil, heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.26	—	
Pine tar, thin, sp. gr. 1.060-1.080	gal.	.30	—	
Turpentine, crude, sp. gr. 0.980-1.000	gal.	.40	—	
Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990	gal.	.19	—	
Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08	gal.	.19	—	
Wood creosote, ref. f.o.b. Florida	gal.	.31	—	

Vegetable and Other Oils

China wood oil	lb.	.19½	—	.20½
Cottonseed oil, crude	lb.	.17½	—	.18
Linseed oil, raw, cars	gal.	1.28	—	
Peanut oil, crude	gal.	1.37	—	
Rosin oil, first run	gal.	.35	—	
Rosin oil, fourth run	gal.	.66	—	
Soya bean oil, Manchuria	lb.	.18	—	.18½
Turpentine, spirits	gal.	.49	—	

Miscellaneous Materials

Barytes, floated, white, foreign	ton	40.00	—	50.00
Barytes, floated, white, domestic	ton	30.00	—	36.00
Beeswax, white, pure	lb.	.56	—	.64
Casein	lb.	.22	—	.30
Chalk, light, precipitated, English	lb.		—	
Feldspar	ton	8.00	—	12.00
Fuller's earth, powdered	100 lb.	1.00	—	1.50
Ozokerite, crude, brown	lb.	.65	—	.75
Ozokerite, American, refined, white	lb.	.75	—	1.00
Red lead, dry, carloads	lb.	.10	—	.11¼
Rosin, 280 lb	bbl.	7.00	—	
Soapstone	ton	10.00	—	12.50
Talc, American, white	ton	15.00	—	22.00
White lead, dry	lb.	.09	—	.10

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	Nominal		
Chrome cement, Grecian	net ton	Nominal		
Clay brick, 1st quality fireclay	per 1000	50.00	—	55.00
Clay brick, second quality	per 1000	35.00	—	40.00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined	ton	35.00	—	36.00
Magnesite, Grecian, dead burned	net ton	85.00	—	90.00
Magnesia brick, Grecian, 9x1½x2½	net ton	135.00	—	140.00
Silica brick	per 1000	50.00	—	60.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f.o.b. Niagara Falls, N. Y	ton	160.00	—	
Ferrocerium	lb.	18.00	—	
Ferrochromium, per lb. of Cr	lb.	.50	—	
Ferromanganese, domestic	ton	250.00	—	
Ferromanganese, English	ton	325.00	—	
Ferromolybdenum, per lb. of Mo	lb.	5.00	—	
Ferrosilicon, 75 per cent, f.o.b. N. Y	ton		—	
Ferrosilicon, 50 per cent, carloads, del., Pittsburgh	ton	165.00	—	175.00
Ferrosilicon, 50 per cent, contract	ton	100.00	—	175.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	2.35	—	2.45
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.00	—	
Ferrovanadium, f.o.b. works	lb.	4.00	—	5.00

Ores and Semi-finished Products

Antimony ore, per unit		1.60	—	1.75
Chrome ore, 48 per cent minimum, f.o.b. Cal., per unit	ton	1.55	—	1.65
Manganese ore, 48 per cent and over, per unit	ton	1.20	—	
Manganese ore, chemical	ton	80.00	—	100.00
Molybdenite, per lb. of MoS_2	lb.	.2.15	—	
Tungsten, Scheelite, per unit of WO_3	ton	26.00	—	30.00
Tungsten, Wolframite, per unit of WO_3	ton	24.50	—	
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	
Pyrites, foreign	unit	.16	—	.16½
Pyrites, domestic	unit	.28	—	.30

INDUSTRIAL

Financial, Construction and Manufacturers' News

New Companies

THE ALL-STATE CHEMICAL MANUFACTURING COMPANY, New York. Nominal capital, $5,000. To engage in the manufacture of chemicals and allied products. Incorporators: W. Graveur, D. E. Hubener, and F. J. Nice, 525 West One Hundred and Sixty-ninth Street.

THE ALTREN COMPANY, Chicago, Ill. Capital, $10,000. To manufacture chemical preparations. Incorporators: Charles F. Brandel, James M. Rainey, and Walter Bashong, all of Chicago.

THE AMERICAN LEAD BURNING COMPANY, Inc., New York. Capital, $25,000. To engage in a general lead burning business, and manufacture chemical apparatus of various kinds. Incorporators: W. H. and E. D. Simonson, and G. W. Winans, 210 Parkside Avenue, Brooklyn.

THE ATLANTIC POTASH CORPORATION, Dover, Del. Capital, $1,000,000. To manufacture potash and chemical compounds.

BRANDON, HADGES & MCLAIN, New York. Capital, $20,000. To manufacture metallurgical supplies, graphite and carbon. Incorporators: A. C. Head, H. M. Eisenberg, and E. M. James, 2 Rector Street.

THE BROWN SAAL COMPANY, New York. Capital, $10,000. To engage in the manufacture of chemicals and allied products. Incorporators: W. C. Murphy, D. H. Cory, and J. E. Saal, 21 West Forty-sixth Street.

THE BURNS CARTRIDGE MANUFACTURING CORPORATION, Dover, Del. Capital, $500,000. To manufacture cartridges, etc.

THE CENTRAL SMELTING & REFINING WORKS, Inc., Bronx, N. Y. Capital, $50,000. To manufacture smelting and refining metals, etc. Incorporators: S. S. Paymer, J. L. Paymer, and N. Sacks, One Hundred and Thirty-seventh Street and Rider Avenue.

THE CHEMICAL CLAY PRODUCT COMPANY, Daisy, Tenn. Capital, $50,000. To manufacture chemical clay products. Incorporators: L. E., B. M. Hood, and G. S. Keeling.

THE SUPERIOR LEAD & ZINC COMPANY, Kingfisher, Okla. Capital, $150,000. To mine for lead and zinc. Incorporators: Luther V. Smith, S. Scott aand M. W. Hinch.

THE TENNESSEE BAUXITE COMPANY, Hixson, Tenn. Capital, $10,000. To develop bauxite mines estimated to contain about 500,000 tons of aluminum ore and install a drying and concentrating plant. Incorporators: C. W. Fisher, R. H. Hunt, and S. O. Bankson.

THE THOMPSON-WEIMAN COMPANY, Cartersville, Ga. Capital, $600,000. To mine for iron. W. J. Weinman is the principal incorporator.

THE TOPPER BROTHERS IRON COMPANY, Columbus, Ohio. Capital, $200,000. To operate a local iron works. Incorporators: L. L. Goldberg, S. Ornstein, Eugene Morgan, and I and M. Topper.

THE UNIONTOWN FOUNDRY COMPANY, Uniontown, Pa. Capital, $10,000. To operate a local plant. E. R. Floto is the principal incorporator.

THE UNITED STATES SANITARY PRODUCTS CORPORATION, Chicago, Ill. Capital, $100,000. To manufacture chemical compounds, etc.

THE UNITED STATES SMELTING FURNACE COMPANY, of Belleville, Ill., has been incorporated with capital of $50,000 to manufacture and sell smelting and melting furnaces and to smelt and melt ore and metals of all kinds.

THE VALVELESS FLUSH COMPANY, Wilmington, Del. Capital, $300,000. To manufacture flush tanks and devices, etc. Incorporators: F. L., M. E., and L. F. Mettler, Wilmington.

THE WEST COAST GLASS COMPANY, Los Angeles, Cal Capital, $100,000. To manufacture glassware of various kinds. Incorporators: H. R. Jones, Frank C. Ford, Arthur White, G. H. Bessemyer, and R. D. Tiffany

THE WHITNEY MACHINE COMPANY, Winchester, Mass. Capital, $100,000. To manufacture machinery. Incorporators: Arthur E. Whitney, Robert F. Whitney, and Walter C. Goddard, Winchester.

Construction and Operation

Alabama

BIRMINGHAM. — The Connors Steel Company, recently incorporated with a capital of $300,000, is planning to take over and operate the plant of the Woodlawn Rolling Mill, which has been operated by the president of the new company, George W. Connors. The plant will manufacture steel hoops, bands, bars, channels and other steel products.

TALLADEGA.—The Graphite Mills Company has recently taken over the plant and property of the Enterprise Graphite Company, and is planning for the construction of a large new mill on the Hurst property in Clay County to provide for increased capacity. The entire plant of the company will also be removed to this location.

Arizona

BISBEE.—The Copper Queen Consolidated Company is planning for the construction of a large new concentration mill near Warren for the handling of the sulphide taken from Sacramento Hill. At this point there is an immense deposit of the sulphide and the company has started steam shovel stripping.

JEROME.—The United Verde Extension Mining Company is making rapid progress in the construction of a new 1600-ton smelter, the entire works being estimated to cost $3,000,000. The company has also commenced construction of a 12,000-foot tunnel in the Verde Valley for haulage from its mines.

KELVIN.—The Ray-Hercules Copper Company, Ray, is rushing to completion the erection of a large new local copper mill, which will cost, when completed, about $2,000,000.

BISBEE.—The Superior & Pittsburgh Mining Company is planning for the construction of a large new mill at its local properties for the handling of silver-lead ores.

TUCSON.—Roos & Tovote have recently acquired the smelter at Socorro, New Mexico, and are planning for the immediate dismantlement of the plant and shipment to its local works, where it will be utilized as a custom plant, with daily capacity of from 250 to 300 tons of ore.

YUMA.—Operation has been inaugurated in the new concentration mill recently completed at the Red Cloud mine, about forty miles north of Yuma. The mill is of 300 tons capacity, and is equipped with Hendy crusher, Eggleston ball-mill, and three Stebbins dry-concentrating tables. Cris Engle is superintendent.

YUMA.—The Carmelita Mining & Milling Company has commenced the installation of considerable new equipment at its local properties, including hammer-drills, gasoline hoist, Ritz air-compressor, ball-pulverizer, three concentrating tables, and flotation process. The company is planning for extensive development of the seventeen claims which comprise its property. J. A. Marx is superintendent.

Arkansas

KINGDON SPRINGS.—E. N. Stanfield, Oklahoma City, Okla., has recently acquired the Monkey Hill zinc mines, and is planning for extensive development.

California

BAY POINT.—The Pacific Electro Metals Company has contracted with the Great Western Power Company, San Francisco, for supplying power for the operation of the first unit of its new chemical plant now in course of construction. About 4,000 kw. will be necessary for the initial unit.

LOS ANGELES.—The American Can Company is planning for the early construction of a large new plant for the manufacture of cans. The project is estimated to cost $1,000,000, and when completed and in operation the new works will have a capacity of about 3,000,000 cans daily, and will give employment to about 1500 hands.

LOS ANGELES.—The Union Oil Company has commenced the construction of the first unit of its new refinery at Los Angeles Harbor for the manufacture of lubricating oils, gasoline, kerosene, and other petroleum products. When completed the plant will cost about $2,000,000.

LOS ANGELES.—The Warman Steel Casting Company, Douglas Building, manufacturer of electric and crucible steel castings, has awarded a contract for the construction of a new 100-foot addition to its plant. The company is planning to double the capacity of its plant at Huntington Park.

INGOT.—The Afterthought Lead & Zinc Mining Company has recently completed the construction of a large new oil flotation plant, and operations will be inaugurated at an early date. The ore is subjected to two flotations—the first removes the sulphide from the gangue, after which this concentrate is roasted and again floated, when the zinc is separated from the copper. The company is planning for the erection of twenty cottages at the mine for the convenience of its employees. George L. Porter is president; J. T. Robertson is general manager.

KESWICK.—The Mountain Copper Company is planning to double the capacity of its oil-flotation plant at Minnesota station, near Keswick. The enlarged plant will have a capacity of about 1000 tons of ore daily.

OAKLAND.—The Occidental Chemical Company, which is a reorganization of the kelp reduction business of the California Chemical Company, Summerland, is planning for the establishment of a large new plant.

TAFT.—The Richfield Oil Company, which recently acquired the plant of the Phoenix Refinery Company, Bakersfield, is said to be considering the construction of a large new local compressor plant for the extraction of gasoline from high gravity oil.

Colorado

CLIMAX — The Molybdenum Products Company is making rapid progress in the construction of a new mill for the handling of molybdenum taken from its holdings. The company is also planning for more extensive development.

CLIMAX.—The new concentration plant of the American Metal Company, Summit County, for the handling of molybdenum, is rapidly nearing completion, and extensive development work is planned by the company. A satisfactory process of treatment has been perfected, and it is anticipated that a large tonnage of ore will be concentrated during the present year.

DENVER.—Fire recently destroyed a portion of the plant of the Chemical Products Company, Louisiana and South Jason Streets. The destroyed building was used exclusively for the production of vanadium for the British Government, and will be immediately rebuilt. The total loss is estimated at $50,000. Lafayette M. Hughes is president.

PUEBLO.—Plans have been completed and construction will be commenced at once on the new local plant of the Norcross Chemical Company, to be located near Stone City. The buildings include tank houses, acid towers, boiler rooms, and other structures, and will be used for the manufacture of acids, chemicals, and munitions. W. J. Cooper is construction superintendent.

Connecticut

NEW HAVEN. — The International Leather & Belting Company, Middletown Avenue, has had final plans prepared for the initial unit of its new plant, which will be one-story brick and steel, about 50 x 150 feet. The entire project is estimated to cost about $200,000. The company has recently acquired additional property in Middletown Avenue for extensions.

Delaware

WILMINGTON.—The E. I. duPont deNemours Company has recently commenced the construction of its proposed new shell-loading plant at Williamsburg, Va., to execute orders for the Government. The entire project is estimated to cost about $5,000,000.

WILMINGTON.—Fire recently destroyed the punch shop at the plant of the Pusey & Jones Shipbuilding Company, with loss estimated at about $75,000.

Illinois

CHICAGO.—The Chicago Bearing Metal Company, 2234 West Forty-third Street, is making rapid progress in the construction of a new one-story plant at 2216 West Forty-third Street. The structure will be about 100 x 225 feet, and is estimated to cost $15,000.

CHICAGO.—The Universal Concrete Products Company, 122 South Michigan Avenue, has commenced the construction of a new one-story plant, about 80 x 450 feet, on Port Washington Road.

CHICAGO.—The Railway Mine & Supply Company, 332 South Michigan Avenue, has commenced the construction of a new plant at Kincaid to consist of a one-story blacksmith shop, about 65 x 100 feet; one-story foundry, 60 x 375 feet, and one-story assembling works. The new plant will cost about $75,000.

SPRINGFIELD.—The United States Industrial Alcohol Company, New York, manufacturer of distilled spirits for industrial and medical purposes, and which operates a large plant in Peoria, has filed articles of incorporation with a capital of $18,000,000 to operate in Illinois. Of this capital $388,000 will be employed in the state.

Indiana

INDIANAPOLIS.—Fire, on January 23, completely destroyed the plant of the Stewart-Carey Glass Company, with loss estimated at about $150,000.

Iowa

DES MOINES.—Harry Cohen of the Cohen Brothers Iron & Metal Works, 307 East Third Street, and associates, are now organizing a large new corporation to have a capitalization of $1,000,000, for the erection of a large roller mill on the site of the old starch works, East Des Moines. It is said that the new plant will give employment to about 5000 hands when running to capacity.

Kansas

JOPLIN.—The Dick Turpin Concentrating Company, with concentrating plant situated on the Riseling land, just southwest of Joplin, has been acquired by the American Metal Company, and the concentrating plant will be removed to the recently acquired leases west of Baxter Springs. The Dick Turpin mill was erected by D. W. Sparks and associates about two years ago.

TOPEKA.—Fire recently destroyed a portion of the plant of the Pioneer Waste Paper Company, Ninth and Adams Streets, with loss estimated at about $10,000.

CHANUTE.—The City officials have awarded contracts for extensions and improvements in the municipal power plant to cost about $25,000. G. G. Wood is city clerk.

Kentucky

PADUCAH.—T. N. Hazelip and E. C. Phelps have leased extensive fluorspar properties in Crittenden County, Kentucky, and Hardin County, Illinois, and are planning for development of the mines.

Louisiana

SHREVEPORT.—The Marine Oil & Refining Company is said to be considering the immediate construction of a large new oil refinery. It is anticipated that the new plant will be ready for operation by the middle of the summer.

Maryland

BALTIMORE.—The United States Industrial Chemical Company has had plans prepared for the construction of a new one-story machine shop, about 80 x 100 feet, at its Curtis Bay works. The new addition will cost $50,000. The company is also planning for a new one-story copper shop to cost $50,000.

BALTIMORE.—The Poole Engineering & Machine Company has recently acquired additional property at its plant for extensions. Additions to the plant now under way are estimated to cost $500,000. The new plant now in course of construction will be used for manufacturing ordnance for the United States Government, and forgings for large guns will be the product of the foundries.

BALTIMORE.— The Bartlett-Hayward Company has acquired a tract of about 40 acres as a site for the construction of a large new plant for the manufacture of munitions. Contract for the new works has been awarded to Morrow Brothers, Fidelity Building, Baltimore.

EDGEWOOD.—The United States Government is having plans prepared for the construction of forty-eight buildings for a new shell-filling station for the Ordnance Department, the entire plant being estimated to cost $4,000,000. The works will include mixing warehouses, supply pumps, chemical and physiological laboratories, etc. The Mellon-Stuart Company, Pittsburgh, Pa., is the contractor

Massachusetts

ANDOVER.—Fire, on January 31, caused by an explosion, destroyed the plant of the Beaver Chemical Manufacturing Company, which was engaged on important work for the Government. The total loss is estimated at about $100,000.

SPRINGFIELD.—The Springfield Gas Light Company is planning for the installation of machinery for the recovery of toluol for Government use in producing trinitrotoluol for explosives. It is anticipated that approximately 30,000 gallons will be obtained annually. Charles H. Tenney is president.

WOBURN.—Fire, on January 30, destroyed a portion of the plant of the Merrimac Chemical Company, with loss estimated at about $10,000. It is said the damaged section will be immediately rebuilt.

Michigan

MARQUETTE.—Fire, on January 29, destroyed a portion of the plant of the Pioneer Iron Furnace Company, controlled by the Cleveland Bluffs Iron Company, of Cleveland, Ohio. The alcohol refining plant, primary building, and several condensers were completely destroyed, with loss estimated at approximately $150,000. This plant was one of the largest producing alcohol and other chemicals for the Government.

Minnesota

BRAINERD.—The Northwest Paper Company is said to be considering the construction of additions to its plant to double the present capacity.

Missouri

CARTHAGE.—Favorable progress is being made by the Pleasant Valley Mining Company, about three miles southwest of Carthage, on the construction of a new concentrating plant. The concentrate at this lease is particularly satisfactory, being lead free, less than 1 per cent in iron, and usually showing about 62 per cent metallic zinc.

KANSAS CITY.—The Winslow Manufacturing Company, manufacturer of tractors, has recently filed plans and awarded a contract for the construction of a new one-story plant, about 50 x 120 feet. The structure is estimated to cost $40,000.

WACO.—Fire recently destroyed a portion of the plant of the Putte-Kansas Mining Company, Jasper County, with loss estimated at $75,000. A section of the new 400-ton concentrating plant, recently completed, was also damaged. The mill will be immediately rebuilt.

Nevada

RENO.—The Consolidated Mayflower Mines Company has been making extensive developments for the production of milling and shipping ore on 200 and 300-foot levels at its Mayflower mine in Nye County, and 1400 feet northwest of the shaft a promising vein has been uncovered near the surface and opened to a depth of 35 feet The vein consists of excellent milling ore, with portions carrying a high gold content. The company will make extensive alterations and improvements at its mill. W. J. Tobin is president.

RAND.—The Nevada Rand Mining Company, located near Rand, is planning for the construction of a large new concentration mill.

New Jersey

MAYS LANDING.—The Bethlehem Steel Company is planning for the immediate construction of a large new local shell loading plant for the United States Government on its property along the Egg Harbor River, and it is anticipated that the new works will be ready for operation in about three months. About 2000 hands will be employed.

DOVER.—The International High Speed Steel Company, one of the comparatively new industries in this section, is now operating its works at full capacity for the manufacture of solid and hollow rock drill steel. The plant is located about two miles from the city, fronting on the tracks of the Lackawanna Railroad.

NEWARK.—The Balbach Smelting & Refining Company, 550 Market Street, has taken out a building permit for the construction of a new brick and steel addition to its plant, about 45 x 64 feet. The company will also make alterations and improvements in its casting and copper furnace works on Ferguson Street.

NEWARK. — The Butterworth-Judson Corporation, Avenue R, manufacturer of chemicals, will build a new one-story engine plant, about 57 x 110 feet, at its plant on Roanoke Avenue. The structure will cost about $25,000.

NEWARK. — The Northern Leather Works & Produce Company, 377 Broadway, New York, is having plans prepared for the construction of the first unit of its proposed new local plant on Backus Street. The structure will be three-story and basement, about 40 x 130 feet.

NEWARK.—The Heller & Merz Company, manufacturer of chemicals, dyes, etc., has filed authorization papers to operate in New York with a capital of $500,000. P. Schnerrenberger, 503 Hudson Street, New York, has been appointed representative.

PAULSBORO.—Construction has been completed on the new plant of the I. P. Thomas Phosphate Company, and it is planned to inaugurate operations at an early date. The structure was erected at a cost of $50,000.

ELIZABETH.—Fire recently damaged a portion of the plant of the Kalbfleisch Chemical Company at Third Avenue and Baltic Street. The destroyed section will be immediately rebuilt.

New York

NEW YORK.—The United States Industrial Alcohol Company, 27 William Street, has recently acquired the distillery of Clarke Brothers & Company, Peoria, Ill., and will make alterations and improvements for the manufacture of chemicals.

LONG ISLAND CITY.—The Central Smelting & Refining Company is having plans prepared for the construction of a new one and one-half-story plant, about 75 x 180 feet, at Borden Avenue, Hayward and Third Streets.

COLONIE.—The Colonie Fibre Company has awarded a contract to Lewis & Bennett, Troy, for alterations and improvements at the plant formerly occupied by Crampton & Beldon. As soon as this work is completed machinery will be installed for the manufacture of woolen fibre.

SYRACUSE.—Fire, on January 27, destroyed a portion of the plant of the Syracuse Rendering Company with loss estimated at $100,000.

MECHANICSVILLE.—The United States Government is planning for the immediate construction of a large new chemical plant to utilize the by-products of the paper manufacturing plants of the West Virginia Pulp & Paper Company. The works will specialize in the production of acetone, which is used to mix with varnish for coating aeroplane wings.

Ohio

CANTON.—Fire recently destroyed the plant of the Miller Pasteurizing Machinery Company, manufacturer of pasteurizing and other dairy equipment, with loss estimated at $200,000.

CARTHAGE.—Three of the five main units of the Hess Spring & Axle Company plant, 124 West Sixty-sixth Street, were destroyed by fire on January 23, with loss estimated at about $100,000.

LEETONIA.—The Fabricated Steel Products Company recently organized with a capital of $150,000, has acquired the plant of the Leetonia Boiler Company, and is planning for the installation of new equipment, including punches, spitting shears and riveters, to provide for increased capacity. The company is engaged in the manufacture of boilers, tanks, wireless towers, and other plate material work for the Government.

LIMA.—Fire on January 29 destroyed a portion of the plant of the Townsend Oil Products Company, with loss estimated at $20,000.

LORAIN.—The J. C. Cromwell Steel Company, manufacturer of steel billets and other steel products, is planning for the construction of five new blast furnaces at its plant to provide for increased capacity

TOLEDO.—The Buckeye Paint & Varnish Company, manufacturer of paints, varnishes, etc., is planning for the early construction of a large new three-story addition to its plant, to provide for increased capacity

Oklahoma

ARDMORE.—The Chickasha Refining Company is making rapid progress in the construction of a large new refinery to have a daily capacity of about 3000 barrels, and it is anticipated to inaugurate operations at an early date.

MIAMI.—The Ken-Tex Company, recently incorporated with a capital of $200,000 to mine for lead and zinc, is planning for the construction of a large new mill.

OKLAHOMA CITY.—The Medical Mining Company, recently incorporated with a capital of $200,000, is planning for the immediate development of about 40 acres of lead and zinc lands and the erection of a 250-ton mill.

Oregon

GOLD HILL.—O. C. Runnalls, Seattle, Wash., and associates, who recently acquired the Utah and Bertleson groups of cinnabar mines, twelve miles north of Gold Hill, are planning to equip the properties with a mercury-reduction plant of 100 to 200 tons capacity.

TAKILMA.—The Atlantic Ore & Alloys Company, Philadelphia, Pa., is planning for the construction of a new plant at the Golconda chrome mine, to have a capacity of about 100 tons daily. Development at these properties has been suspended for the past few months. R. J. Rowan is manager.

Pennsylvania

ALLENTOWN.—Fire, on January 16, damaged the No. 7 tempering plant of the Saucon mill of the Bethlehem Steel Company, used for the manufacture of gun forgings, with loss estimated at $10,000. It is said the destroyed section will be immediately rebuilt.

PHILADELPHIA. — The Philadelphia Paper Manufacturing Company is planning for extensive alterations and improvements at its plant to provide for increased capacity. The work is estimated to cost $25,000.

PHILADELPHIA. — Fire recently destroyed a portion of the glass manufacturing plant of H. Perlstein, 510-18 South Randolph Street, with loss estimated at $50,000.

PITTSBURGH.—The Carbon Steel Company has taken out a building permit for the construction of a large new coal gas producing plant on Putney Way, between Thirty-second and Thirty-third Streets. The new works will be of steel and concrete construction, about 35x185 feet, and are estimated to cost $225,000.

PITTSBURGH.—The Eagle Paint & Varnish Company, 225 Galveston Avenue, manufacturer of paints, varnishes, etc., has recently completed alterations and improvements at its plant to provide for increased capacity.

TYRONE.—The United States Government is planning for the construction of a large new plant on local property owned by the West Virginia Pulp & Paper Company, to be devoted to the manufacture of alcohol and other chemicals from the liquor in which wood is prepared. The new plant will give employment to about 250 hands. The works will be taken over and operated by the West Virginia company as soon as the Government desires.

WILLIAMSPORT.—Fire recently destroyed a portion of the plant of the National Foundry & Manufacturing Company, which was engaged on some important work for the Government. The loss is estimated at about $40,000, including the destruction of some valuable patterns. The destroyed section will be immediately rebuilt.

Rhode Island

PROVIDENCE.—Fire recently destroyed a section of the plant of the Providence Dye Works, South Angell and East River Streets, manufacturers of dye-stuffs, with loss estimated at about $35,000.

Tennessee

CHATTANOOGA.—The Tennessee Bauxite Company, recently organized, has acquired the lease of a large deposit of bauxite which has recently been operated up near Hixon, and is planning for immediate development. The mine is located about fifteen miles northeast of Chattanooga, near the Tennessee River.

COLLINWOOD.—The Tennessee Iron & Railroad Company is planning for the construction of a large new plant to be devoted to the manufacture of wood alcohol, acetic acid and acetone, with charcoal as a by-product. The plant will be owned by the Government, which will utilize all the product with the exception of the charcoal, which the Tennessee corporation will use for fuel in its iron furnace now under construction. The project will cost about $800,000.

KINGSPORT.—The Kingsport Wood Reduction Company, recently incorporated by Chicago capitalists, is planning for the construction of a large local plant for the manufacture of wood distillates. Estimated cost of the work is $700,000.

MT. PLEASANT.—The International Agricultural Corporation is planning for the immediate reconstruction of its phosphate plant recently destroyed at a loss of about $15,000.

Texas

RUSK.—T. L. Featherstone & Company, who recently acquired the furnace and pipe foundry from the State penitentiary, are making extensive alterations and improvements, and are planning to inaugurate operations early in the spring, the furnace to have a capacity of about 100 tons of pig iron daily, and the pipe foundry, about 50 tons of water pipe daily.

West Virginia

MORGANTOWN.—The Star Glass Company, near Star City, is planning for the immediate reconstruction of its plant recently destroyed by fire with loss estimated at $100,000.

Washington

HOQUIAM. — R. Thomas, manufacturer of paper and pulp, has made announcement that plans are under consideration for the construction of a large new local plant for the manufacture of wood pulp and paper, to have an initial capacity of about 100 tons of pulp daily.

SPOKANE.—The Coeur d'Alene Antimony Mining Company, is planning for the establishment of a large electrolytic antimony plant for the handling of ore taken from the company's properties on Pine Creek, Idaho. H. E. Jolly is president.

Wisconsin

MILWAUKEE.—The Hummel & Downing Company, Thomas Street and North Cambridge Avenue, manufacturer of box-board and fibre-board, has completed the construction of its new 140-inch paper mill, and operations have been inaugurated. The new plant was erected at a cost of about $800,000.

RACINE.—Fire recently destroyed the main building of the Belle City Malleable Iron Company, with loss estimated at about $75,000.

Wyoming

RIVERTON.—The Riverton-Wyoming Refining Company is planning for the construction of a large new oil refinery to cost about $127,000. Plans for the plant, which will have a capacity of 3,000 barrels, are being prepared.

Alaska

TREADWELL.—The Alaska Treadwell Company is planning for the immediate installation of new equipment at the Treadwell molybdenite mines at Shakan for early development work. It is said a new concentrating plant will also be erected.

Canada

SUDBURY.—The British American Nickel Corporation is making rapid progress in the construction of a new electrically-operated smelting refinery, which will have a capacity of 2,500 tons of ore daily and a nickel production of 20,000,000 pounds per annum.

PORT COLBORNE, ONTARIO.—The International Nickel Company has commenced the erection of a large new refinery which is estimated to cost $4,000,000, to have an initial capacity of 15,000,000 pounds per year. It is anticipated to inaugurate operations within the next few months.

Trade Notes

HESS & SON, Philadelphia, Pa., manufacturers of Tinol paste solder, wire solder, alcohol torches, and flux, and epicassit, have removed to 1302-4 Filbert Street, where increased manufacturing facilities are available.

THE DRIVER-HARRIS COMPANY, Harrison, N. J., announces that it is now prepared to supply 99 per cent cold-rolled pure nickel sheets. On Jan. 1, there was distributed to all employees having been with the company at least six months on that date a life insurance policy to an amount of $500. It is the intention of the company to make further distribution of these policies as other employees reach the six months service period. The fourth annual dinner of the company was held at the Down Town Club, Newark, on Friday evening, Dec. 28, and was a very enjoyable affair. The entire office staff and the heads of the factory departments, and veteran employees of the company were invited. The number participating was approximately 146 persons. After dinner was served and some short speeches were heard, the evening was devoted to dancing and recreation.

DYESTUFFS IN THE TRADE OF SIAM.—Aniline dyes are not manufactured in Siam, according to a consular report, and the native vegetable dyes with which the Siamese in the past produced the enduring, bright, and beautiful tints on their homemade garments are now being displaced largely by imported dye-stuffs. Dyeing in black, however, is still an important industry in Bangkok. Considerable quantities of silk piece goods are sent from China each year to be dyed in the juice of the green berries and leaves of the native tree "maklua" (*Diospyros mollis*). This imparts to the fabric a bright jet-black color which will stand washing. Stuffs dyed in this preparation are enhanced in value. Siam's imports of dyes of all sorts for the years ended March 31, 1914, 1915, 1916, and 1917 were: For fiscal year 1914, 563,090 pounds valued at $70,936; for 1915, 459,033 pounds valued at $49,590; for 1916, 736,876 pounds valued at $50,166; and for 1917, 974,845 pounds valued at $87,360. The imports for the fiscal year 1917 consisted of 102,418 pounds of aniline colors valued at $34,126; 805,252 pounds of indigo valued at $40,197; and 67,185 pounds of all other dyes valued at $13,037. Of the aniline imports for last year 88,102 pounds were shipped from Holland, and 11,636 pounds from the United Kingdom. Nearly all shipments during 1916-17 were made from oriental ports. There were no exports of dyes from the United States to Siam during that period.

THE PRATT ENGINEERING & MACHINE CO. of Atlanta, Ga., has changed its New York office from 61 Broadway to 25 West Forty-fourth Street.

Manufacturers' Catalogs

THE TITANIUM BRONZE CO., INC., 504 Marine Bank Bldg., Buffalo, N. Y., has issued a booklet describing its method of manufacturing phosphor bronze castings.

BACHARACH INDUSTRIAL INSTRUMENT CO., Pittsburgh, Pa., has issued a pamphlet describing "hydro" gas meters.

LINK BELT CO., Chicago, Ill., has issued a booklet entitled "The Ideal Drive for Rubber Mill Machinery."

KAESTNER & HECHT CO., Chicago, Ill., have issued an attractive catalog describing their line of paint machinery, including mixers, mills, tanks and special apparatus.

RUBBER INSULATED METALS CORPORATION, Plainfield, N. J., has issued a pamphlet describing "Rimco" rubber insulated pliers.

PYROLECTRIC INTRUMENT CO., Trenton, N. J., has issued circular No. 9, describing the Northrup millivolter for accurate e.m.f. measurements up to one volt.

New Publications

NEW GEOLOGICAL SURVEY REPORTS: Fluorspar and Cryolite in 1916. By Ernest F. Burchard; Gold, Silver, Copper, Lead and Zinc in California and Oregon in 1916. By Charles G. Yale; Gold, Silver, Copper, Lead and Zinc in Montana in 1916. By V. C. Heikes; Gold, Silver, Copper, Lead and Zinc in New Mexico and Texas in 1916. By Charles W. Henderson; Gold, Silver, Copper, Lead and Zinc in the Eastern States in 1916. By James M. Hill; Gold, Silver, Copper, Lead and Zinc in Arizona in 1916. By V. C. Heikes; Mica in 1916. By Waldemar T. Schaller; Sand and Gravel in 1916. By R. W. Stone; Zirconium and Rare-Earth Minerals in 1916. By Waldemar T. Schaller.

NEW BUREAU OF MINES TECHNICAL PAPERS: No. 158, Compressibility of Natural Gas and Its Constituents with Analyses of Natural Gas from 31 Cities in the United States. By G. A. Burrell and I. W. Robertson. No. 155, Gypsum Products, Their Preparation and Uses. By R. W. Stone. No. 174, Suggestions for the Safe Operation of Gasoline Engines in Mines. By R. H. Kudlich and Edwin Higgins. No 133 Directions for Sampling Coal for Shipment or Delivery. By George S. Pope. Methods for Increasing the Recovery from Oil Sand. By J. O. Lewis. Bulletin 148 issued by the Department of the Interior, Washington, D. C.

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Discipline

OCCASIONALLY an American has been both bold and frank enough to remind us that as a nation we have a distaste for discipline and a lack of respect for authority; but our complacency has shed the criticism as effectually as a duck's back turns water. Having given no heed to our own critics, perhaps we will the more gracefully accept the same sentiment when expressed by a friendly but earnest ally.

It would have had a salutary effect if every intelligent man in this nation could have been sobered by the direct challenge of Capt. Hodder-Williams, of the British Expeditionary Force, when he told the mining engineers assembled in New York that America's greatest need was discipline and that without it we could not hope to win the war. He spoke as one who has been tried by fire and who knows what it is to lead troops in whose discipline there could be no question. He stated the problem tersely when he explained that discipline must extend beyond the army throughout the whole people, and he illustrated this need clearly when he said that the allied armies would take care of the German military forces, but that the American people must match the German people in discipline—discipline in saving, discipline in co-operation, discipline in sacrifice, discipline in service and discipline in loyalty to the government. The German people are disciplined, and that quality has told in their favor. We too must achieve that end, self-taught because no stern, harsh and rigorous government has trained us. We may scorn the outward and visible signs of discipline, but we must learn to value the inward grace. The great task set for the American people by our ally is self-discipline.

A Little Homily on the Tariff

AT A MEETING of the editors of technical journals held in Washington some time ago, Chairman Taussig of the United States Tariff Commission impressed urgently upon those present the fact that the commission was the creature of Congress and that its function was to present facts. "Our business," said he, "is to gather information, and submit reports to Congress to enable the Congressional Committee and the legislative bodies to deal knowingly with the problems that are presented to them." He said many other things, some of which were confidential and others for publication, and his exposition was at once able and thoughtful. But let us content ourselves with the foregoing as a text, and consider some features that relate to it, most of which he did not mention.

When a tariff bill reaches Congress it has a hard row to hoe because the agents of special interests are always present, and they move to amend in such a way as to benefit the constituent or friend of the amending

representative. It is likely that the information available from the commission will aid in preventing jokers and trades between Congressmen because the proper co-ordination of facts leads to the truth, and when the truth is made intelligible in this manner tinkering becomes difficult.

We know very well that Congress can, by a single enactment, ruin a large part of American industry. There is no reason to think that it will, unless bolshevikitis becomes epidemic in this country, and in that event it will not make much difference what the laws are. But even with our faces turned toward the morning and with hope alive within us, there is one thing of which we may be sure; and Congress is bound to be very sensitive about it because the people at large are growing increasingly so. It will not do any more to "put something over" upon Congress. The general welfare must be considered and not that of special interests. If a heavy duty on some article made here under difficulties is likely to cripple industry at large, it becomes the obligation of the industries that use the product to look out for this link in their chain of needed materials to the end that they can get it made here at a reasonable price. If Congress is asked to make it duty-free, very likely it will—and then it will proceed to make other things duty-free. Congress does not always discriminate with nice precision. If a high duty is imposed, then industry at large will want higher duties to meet the increased cost, and that is the road of danger that leads along the line of soap boxes from which orators call for unconditional free trade and free love and free property.

The Tariff Commission can give no aid in this connection.

Another feature of leading importance that calls for an entirely new angle of vision from manufacturers is the relation of tariff duties to wages. The old line of argument was to generalize and to claim maximum duties for the benefit of the American workingman, no matter whether he got the benefit in whole or in part or not at all. The Commission, on the other hand, will look for the specific relations of labor to product; and generalizations fall down in the face of co-ordinated facts unless they support them. It will examine the relation of import duties to wages in detail; it will exhibit facts instead of claims. Heretofore the welfare of labor has occasionally been used as an argument to cover paucity of research on the part of American manufacturers. That will not do any more. American products must take their places beside those of foreign make and stand or fall by the comparison. Shiftless factory practice and wasteful processes will display themselves without mercy. Scientific research in foreign laboratories must be met by research in American laboratories and these results must be applied to factory practice. This war is causing the whole world to grow very much in earnest. It will not do to regard the tariff, as it frequently has been regarded in the past, as a substitute for research. Progressive industry cannot endure such a wrench in its intermediates any more.

In short, with the world sick with grief over death, and weary with the fever of anger and war, it will not do even to think that prosperity may be achieved by legislation alone. Everybody must work, not only hard but with intelligence. There will be no protection for the incompetent.

The Chemical Alliance

IT was necessary to disband the advisory committees of the Council of National Defense because of a law which was passed making it a misdemeanor for anyone acting in an official advisory capacity to the government to counsel the purchase of wares produced by an organization in which he is interested. Inasmuch as the committees comprised the leading manufacturers of the country no other course was open. At the same time a great deal of useful work had been started, and it was suggested that to meet the needs of the government each industry proceed to organize itself. The Chemical Alliance was proposed for the chemical industry as a whole and this received the hearty approval and encouragement of the War Industries Board, more particularly Mr. Baruch, who, as Commissioner of Raw Materials, has to do with the purchase of chemicals.

There was a considerable number of organizations already established, and without taking the place of these—none of which covered so wide a field—the Alliance sought to profit by their facilities as much as possible. Two noteworthy organizations were those of the fertilizer manufacturers which has active headquarters in Washington, of which Mr. Horace Bowker is the head, and the Manufacturing Chemists' Association, of which Mr. Henry Howard is chairman of the executive committee. At the first annual meeting which we reported in our last number, these gentlemen were elected respectively president and vice-president of the Alliance, and a board of directors consisting of men who occupy the first rank in chemical industry was chosen.

The Alliance has a great deal to do, as we shall observe in the enumeration of some of its problems.

There is co-operation with the government through the Army, Navy and War Industries Board in the continuation of statistical work. An important feature in this connection is the revision of the forms sent to manufacturers for the purpose of gathering information. The forms as prepared have overshot their mark in calling for such elaborate detail that large and important corporations cannot furnish it within reasonable time or without serious disturbances to their procedure.

Co-operation with other boards in the matter of foreign pyrites is needed so that the proper distribution of the material when it is received to the points where it is most urgently required at the time, may be provided for.

The question of supply against the increased programs of the War Department is important. If it is resolved to increase the production of certain munitions, the availability of the necessary materials is immediately studied and the most expeditious and economical program is worked out and presented. In this connection the opinions of the leading men in the trade are of distinct value.

The question has occasionally to be determined as to certain materials, whether they are made here or not; if they are made, who makes them; and if not, who is equipped to make them.

Statements from all the members of the Alliance as to what they can produce constitute information that is far more enlightening than statements of two

or three makers in response to inquiries sent out in the usual manner. This detailed information as to the capacity of an industry, right up to the minute, with the chances of profiteering reduced to the minimum, is something that never has been available before in this country. It also solves problems relating to coal and transportation, showing how the government may supply its needs with the least freight movement. Shipments, for instance, of the same material from one producer in New England to the Middle West and from another producer in the Middle West to New England may thus be avoided in government work at a great saving of time and haulage.

The very delicate question in the case of shortage of supplies as to which industries may be curtailed with least injury to the general welfare is one to be carefully studied and the results contributed to the government authorities if they are asked for.

As chairman of the former Advisory Committee, Dr. Nichols introduced a very profitable method of procedure whereby, at each meeting, the chairman of each section told what had happened within his section since they had last foregathered. This enabled the committee to make studies of products that were bound to be called for, but for which the authorities had not yet formulated their requests. The method has been continued.

In other words, here is a great organization, built up of the leading men in chemical industry, the purpose of which is to help win the war. All manufacturers of chemicals are urgently invited to join it. It is neither a kicking committee nor a profiteering layout. It is the strongest and ablest manufacturing board ever brought together in the United States in chemical industry.

Manufacturers should swallow their fears that competitors may find out something about them and join. We have just one arch-competitor now and that is the German Army and Navy, coupled with the German High Council of Deceit. The only way to beat it is to pull together.

Competition in Steel After the War

LONDON *Engineering* has a very interesting editorial, printed in part elsewhere, as to the prospect of iron and steel competition between Britain and the United States after the war. There is a decidedly able review of what has occurred in the past 30 years, Britain losing her supremacy, Germany coming to the front and the United States failing to make good the promise of 15 or 20 years ago as to its place in the international market, but the editor is less precise when referring to prospects after the war. He inclines to the general belief that costs will be high in the United States, and as to Britain, he is rather oracular—Delphic oracular—in saying that it "rests with themselves," that their statesmen must protect their markets and encourage enterprise; that manufacturers and shippers must organize better and the workmen must adopt a more enlightened attitude.

Without wishing to steal any one's ideas, we venture to observe that the same remarks made about the United States would not be altogether lacking in point. If our government will co-operate with business—and the ice has certainly not merely been broken but melted in the past twelvemonth—not if our manufacturers and shippers will organize better, but if the government will let them, and if our workmen take a reasonable view as to working hard and a decent number of hours, we can do a great deal.

In detail, however, we think somewhat more specific speculations can be indulged in as to American industry immediately after the war, say for a couple of years, than are hazarded by our London contemporary. In the first place, there will be a shortage of shipping. "Ships will win the war," and it seems obvious, therefore, that the war will be won long before there are enough ships for the regular commerce of the world. Demobilization will employ a great many ships, moreover. Export trade will be confined largely to the more valuable and more highly finished products, including machinery, for instance, rather than the tonnage products of the iron and steel industry.

Apart from ocean shipping conditions, the position of the United States in relation to the rest of the world will be altogether altered. Before the war it was necessary to have a large favorable balance in merchandise trade in order to meet various requirements, including payments on American securities held abroad. We quote from the annual report of the Comptroller of the Currency, made Feb. 1, to the effect that since the war started the favorable merchandise trade balance has resulted in our importing about a billion dollars of gold, in practically paying off five billions owned abroad in the shape of American securities, and in our loaning foreign countries two billions, apart from the large advances made by the government itself to our Allies. In such circumstances, merely to "break even" as we did in the past would involve our importing much more merchandise than we exported, instead of the reverse as was formerly the case.

The circumstances will be such as to require the keenest effort to maintain a large export trade. Prices will be high in the United States, the essence of the situation being that the gold dollar will be cheap. That will tend to make it difficult for us to export, but easy for us to conduct a large domestic trade. A very large consumption of iron and steel will naturally be involved. It is natural that our friends abroad should wonder what we are going to do with our surplus when we increase productive capacity as we have done in the past two years. We have pondered the same idea ourselves. In previous cases of expansion, however, we found employment for the surplus at home after all. Our foreign trade did not grow in the past in keeping with our expanding production.

In the matter of international competition we have, perhaps, even greater obstacles to overcome than our London contemporary considers. The period was very brief when we made particularly cheap steel. It was when we were using Mesabi ore from just beneath the surface, with a ridiculously low cost of mining, and ore that was very much richer than what we are forced now to use. More ore must be transported per ton of pig iron, and much more limestone and coke used. Measured in absolute units of effort expended and equipment used, not in the fluctuating standard of the gold dollar, our cost of producing steel is much higher than when we made our reputation in the closing years of the nineteenth century.

Factors in World Trade Competition

A CRITICAL analysis of world trade in iron and steel recently appeared in the editorial columns of *Engineering* (London), from which we make the following excerpt:

The future race for supremacy in the iron, steel and engineering export trade, the world's most important group of manufacturing industries, will probably be mainly between the United States and the United Kingdom. In the last thirty years before the war the Germans increased their output of iron, steel and engineering products, measured in terms of pig-iron, from 3,000,000 tons a year to 19,000,000 tons. In the same period we only increased our output from 8,000,000 tons a year to 9,000,000 tons. In the last fifteen years before the war the protected, organized and subsidized German trade increased its exports of iron and steel goods from less than 1,000,000 tons a year to 6,000,000 tons, while we in those fifteen years only increased our exports of iron and steel from 3,500,000 tons a year to 5,000,000 tons. We lost the lead because we failed to protect our industries, failed to organize, and failed to work hard. Our statesmen would not give productive industry the slightest protection or encouragement, or even the commonest of fair play. Our manufacturers and shippers would not drop their conservatism, or sink their individualism and co-operate for the common good. Our workmen lost 100,000,000 separate working days by strikes in ten years; they opposed machinery; they limited apprentices, and deliberately "slow-timed" their work. After the war we have to protect and organize and develop our industries on common-sense lines, work diligently, enter into preferential trading arrangements with our Colonies and Allies, and avoid German goods. We have to wake up and do these things or perish. We can easily beat Germany if we try * * * but there remains the question of American competition.

It is, therefore, useful to examine broadly the comparative resources of the United States and the United Kingdom. Roughly, there was a world's export trade in iron and steel aggregating 18,000,000 tons a year before the war, valued at more than £200,000,000, besides machinery valued at another £20,000,000. In round figures, Germany was exporting 6,000,000 tons of iron and steel annually; Britain, 5,000,000 tons, and America, 1,500,000 tons. After the war it is more than probable that this trade will be greater in volume and much greater in value than before the war. It is highly likely that Germany's share will be much smaller than it was before the war, which means that more will stand to be divided between the United Kingdom and the United States. By the way, these three countries—America, Germany and Britain—produce somewhere about 85 per cent of the world's total of iron, steel and engineering products. Until the outbreak of war the United States, although possessing a productive capacity equal to that of Britain and Germany put together, never had more than a meager share of the world's export business, as indicated by the above figures. But the opinion is strongly held in some quarters that America will henceforth undertake an export trade in some way commensurate with her capacity of production. What are the prospects? Briefly, it may be said that in abundance of natural resources and in amplitude of productive capacity, the United States is in a position to undertake something like the lion's share of the steel export business, easily beating both us and the Germans; but that in geographical compactness, in the powers of cheap production, and in shipping facilities Britain is much better situated. The United States has the most coal and iron ore. The United Kingdom has the best assemblage, manufacturing and shipment accommodation.

In order to weigh up the position and prospects it is necessary to take a glance backwards. Between fifteen and twenty years ago, while the resources of America—and of most other countries, for that matter—were egregiously exaggerated, not only by American, but by our own public speakers and writers, our own resources were just as absurdly underestimated. It was boldly declared that America could produce the cheapest steel; that we were rapidly becoming industrially bankrupt through the exhaustion of our coal and iron supplies, and the United States would soon flood the world's markets with manufactured goods at prices we could not touch. But the threatened "American Invasion" did not materialize. The Americans vastly increased their capacity. Between 1900 and the outbreak of war they increased their steel works capacity, in terms of pig-iron or steel ingots, from 15,000,000 tons a year to nearly 40,000,000 tons. But they exported very little more in 1914 than they did in 1900. The bulk of the world's export business had gone to the Germans. Relatively, the Americans declined from a promising second to a bad third place in the race, whilst the Germans went rapidly ahead from third to first place, and we fell from a long lead to the second position. If we had paid less attention to the threats of American competition, to the exaggerations of the resources of other countries, and to the scares about our own supplies of raw materials, and had kept our industries advancing concurrently with the world's growing demand for manufactures, we should never have been beaten by Germany, nor need we have feared the competition of any other country. Although our combined productive capacity was less than that of the United States, we exported something like 10,000,000 tons of iron and steel a year, against America's 1,000,000 tons to 1,500,000 tons.

Now, in view of the coming new international competition, it is of prime importance to inquire why the United States, with such a huge capacity of production, has taken such a meager share of exportation business. The reason is that our American rivals have been unable to produce and ship steel goods at competitive prices, notwithstanding all their great natural resources. And this brings us to the central and supreme fact in the issues involved. With their iron ore deposited a thousand miles from their coal mines, and their iron and steel works mostly between 400 miles and 500 miles from the seaboard, and with wages and salaries exceedingly high, the Americans have not been able to sell at a profit, or at competitive prices, outside their own protected home market. Just as the Americans rapidly increased their works capacity, so the costs of their manufacture advanced.

From time to time we hear a great deal about the superiority of American labor, but the figures given in this connection are misleading. They make no due allowance for the vastly greater expenditure on machin-

ery and automatic appliances in America, compared with Britain. If half what we have been told so often about American efficiency and economy had been true, British goods would have been swept clean off the world's markets long ago. The simple fact is that the Americans cannot produce and ship general manufactured goods so cheaply as we can. Some high authorities hold the view that one economic effect of the war will be so to enhance our costs as to enable the United States to produce and ship at least as cheaply as ourselves and the Germans. Many American enterprises and associations are laying their plans in this belief. Much, if not everything, will depend upon ourselves. If we stick too closely to old methods and policies we may be beaten both by American and Germans, not to mention other nations. If our statesmen will not protect our markets and encourage enterprise more than they did before the war, if our manufacturers and shippers will not organize better, and if our workmen will not adopt a more enlightened attitude toward machinery and large-scale production, we shall certainly be beaten. But with anything like intelligent co-operation between the state and industry, and between capital and labor, we should again obtain and retain supremacy in the world's export trade. While the Americans should enjoy highly prosperous trade in their own rich, protected home market, and obtain a considerable share of international business hitherto done by the Germans, we should easily take a long lead in the trade in manufactured exports, and also in shipping.

The Administration Water-Power Bill

IT WILL be interesting to relate some of the facilities that are available for water-power development, the reasons why they are not developed, and to point out what is necessary to bring this about.

The occasional River and Harbor Bills that have been brought before Congress have been justly criticized. They provide in part for prospective river transportation with but rare provision for the use of the power available at or near the dams. Vast sums have been appropriated and some work has been done here and there in the hope that tug boats and wooden or steel barges would come along and carry things—but in the main they haven't come along.

The waterways and power sites of the country are under three departments of government. The navigable rivers, including those that are prospectively navigable —that is, extensions that may be made by dredging, digging canals and the construction of locks and dams —are under the jurisdiction of the Secretary of War. This jurisdiction is changeable and may be extended or withdrawn according to his judgment. The waterways which extend through public lands are under the jurisdiction of the Secretary of the Interior. Those in the national forests are in the keeping of the Secretary of Agriculture. This divided authority has discouraged progress.

To get at the matter more concretely, consider the situation in regard to some thirty-two rivers now held to be either navigable or prospectively so, which are under the jurisdiction of the Secretary of War. The list does not include the Hudson or any stream which has reached its possible development. On these thirty-two rivers alone there is 10,183,950 hp. available. The development of this would add the possibility of 4324 miles of navigable waterways, in most cases where they are greatly needed. In providing for water-power developments by private capital it is right and proper that the interest of navigation be made a part of the contract. The cost to the government for building the necessary canals is then but a fraction of what it would be under the old River and Harbor Bill method, because dams and slack water are already provided by the water-power enterprises.

Another advantage to transportation that would accrue is that reinforced concrete barges may be built very cheaply within a short time and the means of propulsion of such barges is often available at the waterpower sites. When we burn coal to make steam to push a boat ahead a vast amount of energy is lost in pushing the water back. With proper electric towing facilities this energy is not lost, and the question of transportation of heavy staples in the open season by rail drops out of consideration except where the traffic is too light to bear the cost of installation.

Abundant and cheap water transportation thus becomes available as soon as our water powers are developed. Log-rolling and inertia are likely to disappear as soon as a proposal of this sort becomes concrete and the public knows what is to be expected of it. Then the completion of the whole will be demanded instead of the wasteful expenditure of money for the major purpose of bringing it into circulation in local districts.

Now of these water-power resources of 10,183,950 hp.—and they are nearly all attractive engineering possibilities—there are already developed, so far as we are able to gather, 611,141 hp. Over 9,500,000 available horsepower on these thirty-two rivers is undeveloped. The mileage of canals already built is insignificant.

Why is this? First, let us remember that it takes far more effort to build a great machine and to start it than it does to stop it and break it down. A monkey wrench or some emery powder or any one of a great many insignificant things can stop a machine. It is the same with the machinery of capital in great undertakings. Capital invested in water-power propositions is a long time investment. It does not turn itself over every year or even oftener than once in eight years. It is necessary that the fee or title to such property be good because the sums required are very large and the investor cannot get in and get out like a trader on the Stock Exchange. Titles to water-power developments have always been rather complex in this country. The United States Government is sovereign, and licenses can be recalled, although it was held that they would not be. With this in view, from ten to fifteen years ago the prospects for the construction of water-power installations were very favorable, and many projects were under way. But on February 27, 1909, the Hon. James R. Garfield, 2nd, then Secretary of the Interior, withdrew the permits to twenty-five water-power grants on the ground that it was desirable to bring all licenses under new and more restricted rules. The effect upon further developments was disastrous, not because of new restrictions, but because, after all, the government might and in fact did withdraw licenses after they had been granted. That is

what threw the scare into capital. We are not condemning Mr. Garfield; he did what he thought was right, without doubt; but he certainly gave a jolt to the growth of water-power developments.

Another cause may be found in the fashion and style of the thought of the day. It has been and still is held to be contrary to public policy to allow anyone or any corporation which enjoys a special permit or license from the government to grow very rich. We shall make no comment upon this fashion; it is in vogue and we should be only wasting our substance in opposing it, while it does not need our aid in its growth.

Our present laws controlling the development of navigable streams give tenure for a maximum of 50 years, but at the end of that time the United States Government may not only take over the property without compensation, but even charge the licensee with the cost of dynamite to blow up his dam. The result of all these causes is hardly less than an embargo on the industry.

In the last Congress the Shields Bill in the Senate provided a plain contract for 50 years on "navigable" streams (the term being used in the sense of the War Department as indicating also those prospectively navigable). At the end of such time the government was to have the option to take over the works at a fair value, or, if this was not done, the original grantee was to remain in possession for an indeterminate time subject to the pleasure of the government. It provided for the regulation of rates of service and maintained that navigation was of paramount interest. It provided also among other things that if Congress should cancel the grant the owner should be indemnified for his investment at a fair value.

This met with violent opposition from Mr. Gifford Pinchot and his followers; one of the principal objections being that the grants would be, in effect, perpetual investments, as the inertia of government would be too great to provide for taking over the property after 50 years. It was also held that the government should not pay for appreciation in value.

This year an administration bill has been introduced which is full of merit. It provides a commission of the Secretaries of War, Interior and Agriculture, who shall be in a position to give a license for 50 years. At least two years before the expiration of the term the licensee may apply for a new grant. This the government may allow or it may take over the property at a fair value not to exceed the actual cost, or a new license may be granted to a third party who shall pay to the original licensee a fair value not to exceed actual cost or, again, a new license may be granted to the original licensee under the terms of the then existing laws. The Commission may impose a rental for such sum as it may determine, but at a minimum of 10 cents per horsepower-year.

The measure as a whole, which includes supervision of rates and service, is an excellent one with the exception of certain features which may be eliminated; or they may have to be included by way of compromise. The 10 cents per horsepower-year is a light tax, but it has the effect of discouraging the development of reserve power before it can be sold. If the incidence of this or even a higher tax were to apply as soon as power is sold rather than as soon as it is developed, it would appear to be better.

The main thing is to get the bill passed. It provides a 50-year contract, irrevocable except for just causes, and with some small changes in minor particulars will make of water-power developments a fair banking proposition. Control of rates and service is now an accepted factor in public service corporations and the hazard of confiscation by burdensome impositions is no greater than with others. A secure title is absolutely necessary and this seems assured for 50 years.

It would seem reasonable to hold, with rates and service under supervision and with publicity in financing and accounting provided for, that security of possession and the avoidance of actual loss of investment under recapture at the end of the license, would provide for the lowest cost of organization and consequently the lowest cost of service, and that low cost of service would be reflected in rates. United States bonds sell because they are safe; if there were a question of discount at redemption, the discount would show in the price. The injection of hazards into a security puts it over into the speculative class, depreciates its value at the start, and makes it a rich man's opportunity. If the security is good the bonds are easy to sell, bonuses do not have to be given, the poor man can invest his savings in it and nobody is likely to get surprisingly rich out of it. If the site is good or the power is needed, the investors after all may make good money out of it, and that is, according to a certain prevalent school of political philosophy, a thing to be avoided at any cost whatever.

The passage of this bill, or one with equally fair provisions, is urgently needed. We urge it with all our might in the name of electrochemistry, which bids fair to leave this country if additional water power is not soon at hand. We urge it for American farmers who need cheap water transportation, as do the manufacturers and merchants of the interior. And we urge it for the general welfare.

New Western Office of Metallurgical and Chemical Engineering

FOR the past eight years METALLURGICAL AND CHEMICAL ENGINEERING has maintained a Western editorial office at Denver to enable it to reflect accurately the progress of Western metallurgy. Recently that office has been established at 1101 Newhouse Bldg., Salt Lake City, Utah, in charge of Mr. Ernest E. Thum, a metallurgical engineer trained and experienced in Western practice. Centrally situated in the region west of the Rocky Mountains, Salt Lake City has gained increasing importance as a metallurgical center, and the establishment of our office there will enable us to keep in close touch with developments. Our readers are invited to call upon Mr. Thum for any service he can render.

Coming Meetings and Events

Dyestuff Association of America, Rumford Hall, Chemists' Club, New York, March 6.

American Electrochemical Society, Spring meeting, Southern trip, week of April 28.

American Society of Mechanical Engineers, Worcester, Mass., June 4-7.

American Society for Testing Materials, Atlantic City, June 25-28.

New York Meeting of the American Institute of Mining Engineers

Notable War-Time Gathering of Mining Engineers in Annual Session. Report of Business and Technical Sessions. Sidney J. Jennings Elected President. Fall Meeting to Be Held in Colorado

THE 116th meeting of the American Institute of Mining Engineers, held in New York, Feb. 18 to 21, was a notable gathering of engineers in war time. In many respects the programs had a war interest and value, and the spirit of national service was much in evidence. All things considered, there was a generous attendance from such distant states as Montana, Colorado and Missouri, particularly the last where the preceding meeting was held.

Annual Business Meeting

The tellers appointed to canvass the ballots for officers for the year, beginning March 1, declared the following results: President, SIDNEY J. JENNINGS; Vice-Presidents, HENRY S. DRINKER and ROBERT M. RAYMOND; Directors, F. G. COTTRELL, HENNEN JENNINGS, GEORGE C. STONE, SAMUEL A. TAYLOR and ARTHUR THACHER.

The amendment relating to qualifications for membership in the Institute was carried by a vote of 1123 to 59. Under the terms of the amendment, which has been published in the Institute *Bulletin*, future members will have to meet certain requirements and will be classed accordingly.

Plans were made to hold the fall meeting of the Institute in Colorado Springs, Colo., and vicinity.

SIDNEY J. JENNINGS
President American Institute of Mining Engineers

Entertainment of Members and Ladies

A visit to the new subway workings gave an opportunity to see the methods of excavation and timbering employed in the hard rock of Manhattan Island and the glacial drift of Long Island. In the former case rock excavation was carried on for a new subway beneath one in which a train was passing on an average of every 30 seconds.

Mr. MARK R. LAMB exhibited motion picture views of Bolivian tin mines.

At the war smoker, which was presided over by Dr. A. R. LEDOUX, there were a number of interesting and inspiring addresses. Capt. R. HODDER-WILLIAMS of the British Expeditionary Force reminded the American people of the necessity of discipline, not only in our army but throughout the mass of the people. He was followed by a representative of France who expressed the gratitude of his people for the assistance now being rendered by the United States.

The work of the Fuel Administration was explained by S. A. TAYLOR and M. L. REQUA, the latter having recently been placed in charge of the oil division. Mr. W. L. HONNOLD spoke for the Belgian Relief Commission and explained that during the last six months it had been possible to supply only 60 per cent of the requirements of Belgium and northern France. A total of over $400,000,000 has been disbursed by the commission. The War Minerals Committee was represented by its Chairman, WILLIAM Y. WESTERVELT, who asked support for the bill through which Congress will be asked to grant powers to a mineral administrator.

On Wednesday evening the reception of the incoming and retiring presidents, and the "Hoover" dinner were held at the Hotel Biltmore. President Moore acted as toastmaster at the dinner and called upon Captain Dulieux of the French High Commission, W. I. Hotchkiss of the War Minerals Committee, Bainbridge Colby of the United States Shipping Board; W. S. Miller, geologist of Canada, and Sidney J. Jennings.

The Ladies' Auxiliary of the Institute took charge of entertainment of visiting ladies. On Monday visits were made to the art galleries of Henry C. Fricke and W. A. Clark. A motion picture exhibit of devastated regions in northern France was given on Tuesday, followed by a visit to the Metropolitan Museum of Art. In the evening President-elect and Mrs. Sidney J. Jennings held a reception at their residence. On Wednesday morning Dr. ALEXANDER CAIRNS, representing the Food Administration, gave an illustrated talk on "Feeding the Multitude," and was followed by a speaker for the Commission for Relief in Belgium. Wednesday afternoon there was a theater party for the ladies to see a performance of "Chu Chin Chow."

Trip to Princeton

Thursday was devoted to an all-day trip to Princeton University. Luncheon was served in Proctor Hall of the Graduate College, after which President Hibben of Princeton addressed the audience. He spoke of the fundamental, constructive nature of the work of engineers, not only in war but also in peace. President Moore responded for the institute.

The party was then conducted through the Ground

Aviation School and the scientific laboratories of the university and entrained for New York.

Session on Non-Ferrous Metallurgy

This session was held on Monday morning with G. H. Clevenger in the chair.

The Disadvantages of Chrome Brick in Copper Reverberatory Furnaces, by F. R. Pyne. This paper has already been published in our issue for Jan. 1, 1918, p. 20. The author had found hydraulically pressed magnesite brick preferable to chrome. In discussing the paper, Prof. H. O. Hofman said:

"The paper by Mr. Pyne gives clear evidence of the difficulties the metallurgist is likely to encounter when he tries to recover in the blast furnace the metal from old chromite lining used as a refractory material in the copper reverberatory furnace. It appears that chromite cannot be fluxed at temperatures which usually prevail in copper blast furnaces. This calls to mind the freezing-point curve drawn by M. Simonis of mixtures of chromite and kaolinite. (See *Stahl und Eisen*, 1908, Vol. 28, p. 335.) The chromite used in the experiments contained 52.9 per cent Cr_2O_3, 22.6 FeO, 4.8 Al_2O_3, 9.6 SiO_2, 10.1 MgO; the kaolinite was clay from Zettlitz with 98.5 per cent clay-substance. The eutectic mixture with 35 per cent kaolinite and 65 per cent chromite freezes at Seger cone No. 15 (1435 deg. C.), while kaolinite fuses at cone No. 35 (1770 deg. C.) and chromite at cone No. 42 (2000 deg. C.). The curve indicates that the difficulty in the blast furnace can be overcome by having at the smelting zone a temperature much higher than is usual in copper smelting; a charge composition similar to that prevailing at the Mansfeld copper smeltery—which gives with 23 per cent coke a slag of the composition SiO_2 49.09, (FeMg)O 5.58, (CaMg)O 16.02, Al_2O_3 16.02—might flux and fuse chromite."

Mr. Pyne said that ferrochromium could be made from the chromite and that his company had considered installing an electric furnace for this purpose, but the war had required their attention on other things. Mr. Clevenger said it had been his experience that chrome brick formed a poor furnace lining for electric furnaces operating at high temperature. Mr. Forest Rutherford said he agreed with Mr. Pyne on the metal absorption by chrome brick and on the difficulty of fluxing chrome bats. On the other hand, he said he had found magnesite unsatisfactory for reverberatory furnaces except in the roof. He had used at the Copper Queen Works, Douglas, Ariz., a lining consisting of a layer of magnesite, a layer of chrome and a layer of silica; the latter forming the inner furnace surface. Mr. Stoughton said it was patriotic not to use any more chrome brick than necessary on account of the shortage and the fact that there were certain places where it must be used.

Fine-grinding and Porous-Briquetting of the Zinc Charge, by Woolsey McA. Johnson. The author made some experiments with the idea of reducing the coal and coke used by charging finely-ground porous material. It was reasoned that such a charge could also be much more easily reduced and would have greater heat conductivity. From his experiments he figured a reduction in cost of $5.67, by means of increased charging, resulting from fine-grinding, ventilating and briquetting, assuming a cost of $17 per ton of ore. The reduction in "charge" coal cuts the cost of coal from $2 to $1.20. There would be a certain reduction in furnace labor and also in retort consumption because the charge gives a residue that blows out clean. The recovery will be increased because of low residues and decreased retort-consumption; perhaps this saving will amount to $3. The credits thus total $10.97 while the debit is $1.50; or a total net saving of $9.47 is possible. The briquetting needs a special binder. In the discussion Mr. O. C. Ralston said that the zinc smelters complain of the large amount of flue dust from roasting and that some such method as described by Mr. Johnson would be the solution of the problem. Mr. Hall of the New Jersey Zinc Company asked what binder was used and what per cent. Mr. Johnson said 10 to 12 per cent of sludge acid from oil refining gave good results.

High-Temperature Resistance Furnaces with Ductile Tungsten or Molybdenum Resistors, by W. E. Ruder. This paper described various types of furnaces developed by the Research Laboratory of the General Electric Company to meet the general needs of laboratory work. Since the discovery, by this laboratory, of methods for producing tungsten and molybdenum in ductile form, their use as resistance elements in the Research Laboratory of the General Electric Company has grown to such an extent that they are now almost indispensable. These furnaces are used here for alloy research, annealing, heat-treating, and practically all of the thermal processes requiring temperatures above 900 deg. C. In discussing the paper Mr. Spilsbury asked whether the furnaces were for laboratory purposes only. Mr. Ruder replied that they were, and had been developed originally for heat-treating tungsten. Mr. Hall asked whether the author had used reducing gases in such furnaces. Mr. Ruder said he found trouble getting a tube which would not leak gas at a high temperature.

Zinc Refining, by Leland E. Wemple of the American Zinc, Lead and Smelting Company, St. Louis, Mo. Mr. Wemple first discussed in a general way the impurities in spelter and methods of reducing same, and the need for high-grade spelter since the war began. He then took up redistillation methods which are in use and proposed, and also discussed refining by remelting and the grade of the refined zinc. In the discussion Mr. Spilsbury asked what the total loss was in redistillation, including lead, blue powder and the final remelting. Mr. Wemple said that approximately 5 per cent was lost on the first operation. This is a zinc loss. The lead should not be considered a loss, as it is finally recovered. The by-products run about 15 per cent, consisting of blue powder, skimmings, etc. About 3 per cent of this is scrap and the balance blue powder. The net loss is about 6 to 7 per cent of the zinc content of the charge. Mr. W. McA. Johnson asked what percentage of lead was carried over mechanically and what percentage by vapor pressure. The author had no data but said it was possible to produce zinc with only 0.03 per cent lead by running near the boiling point of zinc, but as the temperature goes higher the lead increases. If not careful 0.25 to 0.30 per cent lead can be produced. The essential thing to keep the lead down to low limits is heat control.

The other two papers presented at this session were *Bone-Ash Cupels*, by F. P. Dewey, of the Bureau of the Mint, and *An Automatic Filter at Depue, Ill.*, by G. S. Brooks and L. G. Duncan. A synopsis of Mr. Dewey's paper appears in this issue, page 260.

Session on Mining and Milling

Hints on Bucket-Elevator Operation, by A. M. Nicholas. This paper gave some practical hints from the author's experience. The settling of heavy pulp in the buckets, with consequent failure to discharge the load, was overcome by agitating the belt about midway of its span. The cutting of elevator belts by sharp rock was overcome by attaching a wooden shield below each bucket to prevent fine particles of rock from falling between the belt and the bucket when the latter passed over the head pulley. A balata belt thus equipped has been in use for two years and has hoisted about 50,000 tons of rock. The slipping of narrow high-speed belts can be prevented by using a belt made of small blocks of leather overlapping at the ends and pinned through with metal pins.

Recent Tests of Ball-Mill Crushing, by Charles T. Van Winkle. This paper was published in extended abstract in our issue for Jan. 15, page 207. It concerns tests of Hardinge & Marcy Mills. In discussing this paper Mr. Parke Channing stated that the problem presented to Hardinge and Marcy was to install crushing capacity for 1000 tons per day, each using two mills. The Miami staff had considered Mr. Hardinge unwise to attempt the test with less than three mills, and the unsatisfactory results obtained by him are attributed to his attempt to do the work with two mills. The original Miami mill had a set of rolls and two Hardinge mills for each section, but later they put three Hardinge mills in each section and the results were satisfactory.

In further discussion Mr. B. Britton Gottsberger submitted a concise statement of the work now done at Miami in a completed section, using three Hardinge mills for fine grinding.

The ore hoisted through the main shaft is dumped into a 1000-ton bin located at the head of the crusher plant. The plant consists of No. 7½ gyratory crushers followed by two sets of rolls 55 in. by 20 in. and 42 in. by 16 in., respectively, operating in closed circuit with trommels fitted with screens having ⅝ in. by 1⅛ in. slotted holes. Practically all of the product produced will pass a ¾-in. round hole, as shown by the average screen analysis for the month of January given below:

Table I.—Screen Analysis of Feed to Ball-Mills

	Per Cent	Cum. Per Cent
On ¾-in. round hole	1.1	1.1
On ½-in. round hole	13.8	14.9
On ⅜-in. round hole	13.7	28.6
On ¼-in. round hole	12.2	40.8
On 3/16-in. round hole	7.4	48.2
On ¼-in. round hole	9.3	57.5
On 10-mesh	8.3	65.8
On 14-mesh	4.4	70.2
On 20-mesh	3.3	73.5
On 28-mesh	4.0	77.5
On 35-mesh	2.4	79.9
On 48-mesh	2.7	82.6
On 65-mesh	2.0	84.6
On 100-mesh	1.5	86.1
On 150-mesh	1.9	88.0
On 200-mesh	1.3	89.3
Through 200-mesh	10.7	
	100	

The product of the crusher plant is carried by belt conveyors to the mill bins located back of each section of the plant with a total capacity of about 10,000 tons. From this point reduction of the ore is carried out entirely in Hardinge ball-mills, three of these machines being installed in each section to handle approximately 1000 tons per day of crusher plant product, which is ground to a point where practically nothing remains upon a 48-mesh screen. The mills used are built of cast iron and are 8 ft. in diameter by 36 in. length of barrel, driven direct by electric motors through Wuest gears. Each mill is equipped with a 150-hp. motor and runs at 20.6 r.p.m.

The grinding is at present done in two stages. The entire section tonnage is first subjected to single-pass crushing through one mill, the product passing to a 4-ft. 6-in. Dorr classifier. The overflow of the classifier is finished product. The sand product of the classifier, representing the oversize of the first mill, is divided equally between two mills of the same size, each operating in closed circuit with a 6-ft. Dorr classifier. The overflow of these classifiers is finished product, the sands being returned to the mills for regrinding. The product produced by this system of grinding is shown by the following average screen analysis of the tailing of Section 6 of the plant for the month of January, 1918:

Table II.—Screen Analysis of Hardinge Ball-Mill Product

	Per Cent.	Cum. Per Cent
On 28-mesh	.9	.9
On 35-mesh	1	1
On 48-mesh	.4	.5
On 65-mesh	3.8	4.3
On 100-mesh	14.2	18.5
On 150-mesh	14.8	33.3
On 200-mesh	6.3	39.6
Through 200-mesh	60.4	
	100	

The average tonnage handled in Section 6 by the three mills during the month of January, 1918, was 987 tons per day of 24 hours. The power consumed in grinding by the three mills according to wattmeter readings amounted to 7475 kw.-hr. per day, equivalent to 7.57 kw.-hr. per ton. The power consumption for the balance of the work done in the total reduction from mine rock is very small. We have no accurate wattmeter readings on this, but according to our regular power distribution, figured from ammeter readings, the power for preliminary coarse crushing, conveying and operation of the Dorr classifiers amounts to 1 kw.-hr. per ton. Therefore, the total power consumption from mine rock to finished product is 8.57 kw.-hr. per ton.

Theory and Practice of Ball-Milling with Peripheral Discharge Mills, by Pierre R. Hines. These notes were based on observations made by the author on a western trip made for the purpose of studying the ball-mill. He finds that balls fall from their maximum free height when the ball charge is about one-third the volume of the mill, and that the greatest number of tons crushed to a certain mesh per kw.-hr. is obtained under that condition. Capacity depends upon fineness of grinding, weight or volume of ball charge, hardness of material, size of grate openings and size of balls, other factors remaining constant. Tonnage and fineness are inter-related and the capacity of a ball-mill should be figured on the following basis when sufficiently reliable figures have been collected. The kw.-hrs. required to crush a ton of ore from and to a certain mesh should be arrived at from average operating conditions. A ball-mill has a certain definite maximum power rating depending upon its ball load. Multiplying the kw.-hrs. per ton by the tons required to be crushed per hour, the product will represent the power required, and the mill nearest to that power rating should be selected. For ball-mill feeding he recommends an apron feeder controlled by a variable-speed transmission device, and a smooth trunnion liner tapering into the mill. For fine grinding the best ratio of water to solids is 1:2 or 1:1½. Ball consumption varies with conditions of ore and grinding, but is about ½ lb. per ton for steel balls and 1 lb. for cast composition balls, when the product all passes 8-mesh and contains 10 to 20 per cent below 200-mesh, the mill running in open circuit. Average consumption of liners, for both chrome and manganese steel, is 1.3 lb. per ton of ore crushed, being fairly constant regardless of conditions.

New Method of Separating Materials of Different Specific Gravities, by Thomas M. Chance. This paper

was presented by Mr. H. M. Chance, who gave a demonstration with a small experimental device. The method is based on the fact that fine sand mixed with water can be maintained suspended in the liquid by continuous agitation, and that this agitated mixture will act like a fluid of high specific gravity, including its ability to float solid bodies of less specific gravity and permit those of greater specific gravity to sink in it. In the apparatus exhibited, agitation was produced hydraulically by pumping water through the sand, and a mixture of coal and slate was readily separated. The method is believed to be of wide application in the mineral industry, and is about to be applied in coal washing.

The last milling paper presented at this session, on the United Eastern Mill, by OTTO WARTENWEILER, was published in this journal, Dec. 1, 1917, page 656.

SESSION ON IRON AND STEEL

The Erosion of Guns, by HENRY M. HOWE. This paper is based on the examination of two rings from an eroded gun liner. It treats of the hardening of the bore by its rapid cooling by the outer metal, the cumulative cracking of the bore, and possible palliatives of erosion. The phenomena are explained by assuming a "temperature cycle," or course of heating and expansion in each round. Following is an extract of the author's summary:

> At any section the cycle begins with the passage of the driving band of the projectile, from which the lips of each crack, hardened in the preceding round and still cool, bite off a mouthful of copper, thus sealing themselves. Next comes extremely rapid heating, expansion, and closing of the cracks, with extrusion of much of the copper. A thin layer of the bore face is melted and swept forward by the rush of the gases, together with so much of the metal outside it as is heated to erodible mobility, the metal removed from any one section being thus replaced in part by that swept forward from rear sections, and this forward sweeping layer keeping all cracks sealed till the bore-face metal again hardens. With this forward sweeping probably goes the entrainment of some of the molten metal in the form of a mist, its bodily removal from the gun, and choke-boring. Thus the erosion at any given section consists first of this misty entrainment, and second of excess of metal swept forward from that section over that swept to it.
>
> In the heating period, brief as it is, some of the initially distinct particles of ferrite and cementite in a very thin layer adjoining the bore face merge to form austenite. The following cooling by conduction into the cold outer metal is so rapid that this austenite is caught in the state of martensite and is thus hardened. It is next annealed during the heating period of the next round and in part eroded and re-hardened in the following cooling. Thus the hardening is repetitive.
>
> The thickness of this hardened layer increases asymptotically from round to round, because the heating in each round extends beyond the layer actually hardened in the ensuing cooling, and in thus extending begins the merging of the ferrite and cementite beyond the layer hardened, and thus facilitates further merging and thus hardening in the next round.
>
> In the cooling of each round the layer which has been fluid or at least pasty cools and hence contracts much more than the outer and cooler metal with which it is integrally united, and thus becomes in effect stretched by the resistance of this strong outer cold metal beyond its ability to retain continuity, and thus cracks.
>
> In the grooves the expansion has to be axisward solely, and the cracking in the subsequent cooling is, therefore, about the same longitudinally as circumferentially. But the forward rush of the gases exaggerates the longitudinal cracks, so that the longitudinal ones are more prominent than the transverse. The expansion of the lands occurs both axisward and circumferentially, and the corresponding circumferential contraction in large part relieves the tendency to form longitudinal cracks, with the result that the main cracks are transverse.
>
> The copper stopping of each crack, and the oxidation of its sides during the period of contraction, cause the cracking to be cumulative, so that the total width of the cracks, including their copper stoppings, is about ten times that corresponding to the contraction occurring in a single round. The transverse cracks on the strongly pressed lands are so much more prominent than those in the grooves, and have such an approach to even spacing, as to suggest strongly that they are exaggerated by chattering.
>
> In the forward lands many of the cracks are filled flush with copper. The rest are black and not filled flush. A copper network projects from the forward grooves. The difference is referred jointly to the continuation of the expansion in the grooves till a later period than in the lands, and to less violence of the gas-rush in the grooves than on the lands, with the result that all the copper ejected by the expansion from the land cracks is wiped away by the gases, while the latest extruded from the groove cracks persists.
>
> The cracking of the bore probably neither hastens erosion nor weakens the gun.
>
> White-hardness and also great thermal conductivity, specific heat, and density, should lessen erosion.
>
> Of the palliatives of erosion, the replacement of the liner seems the most promising.
>
> Though experiments with other alloys of high melting point should be tried, the prospect of success is not great, because the available metals more infusible than iron are thought to yield alloys less infusible than it, and also difficult to machine, costly, and prone to oxidize.
>
> The success of manganese steel in pipe balls in resisting conditions closely like those of gun liners suggests experimenting with it.

Dr. Howe's paper was discussed at length by naval engineers and others, but lack of space prevents publication of the comments.

Transverse Fissures in Steel Rails, by J. E. HOWARD. This paper dealt with fractures in steel rails at right angles to their length. The author regarded them as a modified type of fatigue fractures of interior origin. He explained their occurrence in the light of common knowledge on the behavior of steel under repeated alternate stresses. "By reason of the state of internal compression at the running surface, the maximum tensile stresses in the head, under bending loads, were along an interior element. Here the tensile strains were higher than in the fibers, more remote from the neutral axis. Under such conditions the fracture of the rail would be expected to have an interior origin." The author further stated that neither chemical analysis nor microscopic examination showed a definite cause for development of transverse fissures, and that such fissures developed in rails structurally free from any known defect. The fissures are found where traffic, wheel loads and speed have increased and where these conditions are well advanced.

Considerable discussion was elicited by this paper. Mr. WEYMOUTH found that most rail failures due to transverse fissures occurred in rails of extreme chemical hardness, and suggested adopting rails of different compositions for specific duties. Mr. UNGER suggested the following remedies: (1) Proper support of the rail to prevent alternate stresses; (2) decrease of the load on rails, and (3) an increase in the section of rails. Dr. DUDLEY did not accept the author's conclusion of the origin of transverse fissures and did not believe they were fatigue fractures. Mr. RAY believed that mill practice greatly influenced the development of transverse fissures and thought more attention should be given to the manufacture. He had found that these fissures developed mainly in rails of 0.80 carbon or above.

Session on Metallography

This session was marked by the presentation of a number of highly technical papers which can scarcely be presented in brief abstract. Metallography is making rapid progress under the direction of a comparatively small group of brilliant investigators, and the metallurgical industry will find itself deeply indebted to them as time goes on.

Grain-Size Inheritance in Iron and Carbon Steel, by Zay Jeffries. The author elucidated the following general laws influencing grain size, and illustrated his discussion by citing actual examples.

The grain size of any transformation product in iron and carbon steel due to heating or cooling through the transformation range will depend on:

A. The rate of heating or cooling through the transformation range.

B. The grain size and arrangement of the constituents just prior to the occurrence of any transformation.

C. The chemical and physical composition of the iron or steel product, *i.e.*, carbon content, sonims, gas inclusions, blow holes, etc.

D. The temperature gradient obtaining during the transformation period.

The Time-Effect in Tempering Steel, by A. E. Bellis. The author discussed the relation of reheating to physical properties and machinability of steel, particularly rifle-barrel steel. Tests are cited to show that increasing the time of reheating increases the ductility, toughness and machinability of the particular steels described.

Some Structures in Steel Fusion Welds, by S. W. Miller. This paper is a discussion of conditions observed under the microscope in sections of oxy-acetylene and electric arc welds. It must be studied in connection with the microphotographs.

Effect of Copper in Steel, by Carle R. Hayward and A. B. Johnston. A synopsis of this paper appears in this issue, page 260.

Session on Employment Problems. A new departure was inaugurated at this meeting in the form of two sessions on employment problems. The growing importance of this subject has been realized by the institute, and programs were arranged covering all phases of the labor problem. Some of the points emphasized were the necessity of a thoroughly capable employment manager, adequate living conditions for labor and proper care of workmen while on duty. Other interesting topics concerned the training of workmen for better positions and the crippled soldier in industry. All of the papers are worthy of careful study.

Patent Office Improvements.—A composite committee has been created by the National Research Council to make a preliminary study of the problems of the United States patent office and its service to science and the useful arts. This committee comprises L. H. Baekeland, W. F. Durand, Thos. Ewing, Frederick P. Fish, Robert A. Millikan, E. J. Prindle, Michael I. Pupin, S. W. Stratton. Those interested in making any patent-reform suggestions are advised to forward them at once to Dr. Wm. F. Durand, National Research Council, Washington, D. C. The particular point upon which suggestions are desired is the manner in which greater efficiency and work of higher quality can be secured in the Patent Office.

Spring Meeting of the American Electrochemical Society

At a meeting of the board of directors of the American Electrochemical Society held in Philadelphia on Feb. 22 it was decided to hold the spring meeting in the South during the week of April 28. In accordance with plans previously proposed, the society will make a trip of one week through the chemical, electrochemical and metallurgical centers of the South. Over eighty members and guests have agreed to go. The society was urged by Southern members, heads of industrial concerns and railroad officials not to abandon this trip, all agreeing that it would afford a timely opportunity to study the present development and future resources of the South with respect to national needs. Railroad officials anticipate no difficulty in arranging transportation.

It is planned to leave Washington, D. C., Sunday evening, April 28, and spend one day in each of the following centers or districts: Kingsport, Knoxville and Chattanooga, Tenn., Sheffield and Birmingham, Ala. Programs of technical papers will be presented each evening. On the return trip the party will arrive in Washington Sunday, May 5, in time for individuals to reach their homes Monday morning. Arrangements are in charge of a committee headed by Mr. C. F. Roth, who may be addressed at Grand Central Palace, New York City.

Engineers in Government Service

THE Engineering Council, through its American Engineering Service Committee, has during the past few months supplied to various government departments and bureaus in response to their requests several thousand names of engineers from which men were to be selected to fill a great variety of positions in uniformed and civilian service for Army and Navy and other branches of the government's activities in connection with the war, as well as for indirect service for manufacturers and contractors engaged upon government war work.

To meet these demands the American Engineering Service Committee has assembled in its offices in the Engineering Societies Building, New York, extensive lists and much detailed information concerning engineers in all branches of the profession throughout the length and breadth of the land. It will readily be appreciated that if these lists are to be maintained in the most useful condition to the government and the Engineering Council, the committee should receive promptly information concerning each engineer who has gone into any kind of government service, direct or indirect, so that a record may be made on his cards in the committee's office.

Engineers reading these lines, to whom this request applies, are urged to send at once their names, present addresses and occupations in the government service, with brief statement as to whether or not they are available for other service, to American Engineering Service Committee, Room 901, 29 West 39th Street, New York. Other readers are asked to bring this request to the attention of such engineers or to send information directly to the committee at the above address.

Ultraviolet Energy and Its Use

By M. LUCKIESH
Physicist, Nela Research Laboratory

SINCE the discovery of ultraviolet rays, more than a century ago, their production and properties have been subjected to a great deal of investigation. However, notwithstanding the extensive literature on the subject, we must agree with Sheppard, who says in his book on Photo-chemistry: "We are only at the beginning of the conscious utilization of the powers of light, as distinct from the unconscious enjoyment of them." Owing to the many unique propties of these invisible rays they are extremely valuable in certain scientific investigations, tests, and industrial processes, and it appears certain that, with the progress of the development of sources of ultraviolet rays, and of media transparent to them, the usefulness of ultraviolet energy will be rapidly extended. The problems in which these unique properties may be utilized are so manifold, it appears that a general discussion of the subject may be welcomed at this time. For the sake of clearness in the following discussions, the spectrum will be divided arbitrarily, as follows:

Visible spectrum extends to wave-lengths slightly shorter than 400μμ.

Near ultraviolet will designate the region between 400μμ and 300μμ.

This may be said to be the extent of the ultraviolet spectrum ordinarily encountered because clear glass is, in general, opaque to rays of shorter wave-length.

Middle ultraviolet will designate the region between 300μμ and 200μμ.

Schumann region is that from 200μμ to beyond 100μμ. This region has been studied elaborately by Lyman[1], who has revealed the spectrum somewhat beyond 100μμ.

It is understood that some of these divisions and limits have been chosen arbitrarily for the sake of convenience in the present discussion.

Transparency of Media

The transparency of various media for ultraviolet rays is of importance from the standpoint of the production, measurement, and utilization of this energy. Enclosing media and optical parts must be transparent to the rays to be utilized. Ofttimes filters are desired for isolating certain spectral regions and in many other ways it is of interest to know the spectral transmission characteristics of various media. Of course, the thickness of the medium is an important factor, but where this is not mentioned in the following discussion, ordinary moderate thicknesses will be assumed. In this general discussion it is out of the question to take up this and many other details.

Clear glass varies in its spectral characteristic in the ultraviolet region, depending upon its composition. Most ordinary clear glasses are quite transparent down to 350μμ, but they usually decrease in transparency from this point until they become practically opaque at about 300μμ. The Jena works developed a glass (uviol) which transmitted quite freely down to 300μμ. Fritsch[2] has given a formula for a durable glass which he claimed to be transparent as far as 185μμ. He recommended 6 grams of $CaFl_2$ mixed with 14 grams of B_2O_3 in powdered form. This was melted in a platinum furnace crucible and poured out on an unheated sheet of platinum.

Fused quartz transmits freely to about 220μμ. Crystal quartz is transparent as far as 180μμ. It is thus seen that quartz is only useful for the middle and near ultraviolet regions.

Fluorspar is not only transparent to these regions, but also to nearly all the Schumann region, its transparency extending to 120μμ.

Air absorbs the rays in the Schumann region quite powerfully. Therefore, for most practical purposes quartz is satisfactory. An air-path 1 cm. long is opaque to radiant energy of wave-lengths shorter than about 170μμ. The solar spectrum, even when photographed at high altitudes, ends at about 290μμ, indicating the presence of media in the earth's atmosphere or in that of the sun which are opaque to the rays in the middle and Schumann regions. Lyman presents data on the absorption of gases which may be of interest in this connection.

Snow reflects the near ultraviolet rays almost completely.

A thin veil of smoke is opaque to the middle and Schumann regions.

Gypsum, celestite, borite, sugar crystals, calcite and alum are opaque to most of the Schumann region, their transparencies ending in the neighborhood of 170μμ.

Mica strongly absorbs the rays of short wave-length.

Rock salt is of high transparency at 185μμ.

Gelatine strongly absorbs the rays of shorter wave-length than 200μμ and therefore, for photographic work in this region, non-gelatine plates must be used. It is obvious that an evacuated space also must be provided owing to the absorption by the air.

Pure water is quite transparent to the middle and near regions.

The above-mentioned substances are of interest largely owing to their transparency but certain filters are of special interest owing to their spectral absorption characteristics.

Many optical glasses which are nearly colorless or of a yellowish-green or yellowish tint effectively absorb nearly all the ultraviolet region. Uranium glass is very effective in this respect and by virtue of its fluorescence it is useful in exploring an ultraviolet spectrum especially for such a purpose as focussing a spectrograph. Quartz spectroscopes are sometimes equipped with such fluorescent screens in the eye-piece for visually inspecting the ultraviolet spectrum. A solution of quinine sulphate or of aesculine effectively absorbs the ultraviolet rays and both fluoresce.

Dense cobalt-blue glass combined with an aqueous

[1]Spectroscopy of the Extreme Ultraviolet. Longmans, Green & Co., 1914.

[2]Phys. Zeit. 8, 1907, p. 518.

solution of $CuSO_4$ (which absorbs the red band transmitted by the cobalt glass) isolates the near ultraviolet and violet rays.

Nitroso-dimethyl-aniline dissolved in water is fairly transparent between 280μμ and 400μμ. This may be incorporated in gelatine (6 grams of gelatine to 100 grams of water heated to about 50 deg. C.) and flowed on a glass or quartz plate. The best strength of this filter is one which just eliminates the blue and violet light. This filter may be combined with blue uviol glass and an aqueous solution of $CuSO_4$ for the purpose of isolating the near ultraviolet. In case the glass elements of such a combination are unsatisfactory, quartz plates may be used and a dense solution of methyl violet or other deep violet dye may be substituted for the blue uviol glass.

Many combinations of aniline dye solutions or gelatine filters may be used for isolating the near ultraviolet.[3] For isolating portions of the middle and Schumann regions various gases and other media may be used. For example, Peskov[4] studied the spectral absorptions of chlorine and bromine and found that, by varying a mixture of these two gases, he could isolate regions of the spectrum as narrow as 240μμ to 250μμ. These mixtures were found to follow Beer's law and, therefore, after having obtained the requisite quantitative data, the mixture for filtering a certain spectral range could be calculated.

Metallic silver is opaque to the ultraviolet except for a narrow range near 300μμ to 340μμ. Colloidal silver appears to have a spectral transmission characteristic which differs from that of the metallic film.

Absalom[5] dissolved such metals as K, Na, Li, Cs, Rb, Ba, and Sr in ammonia and obtained blue solutions which had valuable properties as ultraviolet filters. These solutions were quite fugitive but with dry ammonia and freshly scraped metal, Cottrell obtained blue solutions lasting as long as several years. A general result of Absalom's work was that transparency far into the ultraviolet is much more commonly met with in the case of color due to colloidal metals than in the case of ordinary colored salts or aniline dyes. The limit of transmission for liquid ammonia is at about 240μμ. In general for these blue solutions total absorption began in the neighborhood of 245μμ.

Absalom used an arc between copper poles and a small quartz spectrograph and thus was able to photograph a spectral range between 500μμ and 225μμ. He presented the following wave-lengths in μμ as those at which complete absorption commences:

Natural blue rock salt	Beyond 225 μμ.
Natural rock salt colored by cathode rays	Beyond 225
Natural rock salt colored blue by cathode rays	Beyond 225
Sylvite, white	Beyond 225
Chili saltpetre, ordinary white variety	351.2
Chili saltpetre, violet	324.8
Fluorspar, colored deep violet by cathode rays	Beyond 225
Diamond yellow	320
Diamond blue	315
Kunzite	305
Garnet	402.3 μμ.
Zircon (hyacinth) red-brown	261.8
Zircon, decolorized by heat	244.2
Zircon, green	402.3
Zircon, yellow	402.3
Topaz, pale yellow	261.8
Topaz, dark yellow	229.4
Topaz, pale pink-brown	261.8
Topaz, blue	296.1
Emerald	320
Ruby	300
Tourmaline, green	351.2
Tourmaline, green-yellow	300
Tourmaline, pink	306.4
Spinel, blue	402.3
Spinel, purple	324.8
Spinel, pink	300
Kyanite, blue	320
Beryle, blue	327.4
Cordierite, blue-purple	324.8
Cairngorm	324.8

[3] M. Luckiesh, Color and Its Applications, D. Van Nostrand Co 1915, p. 51.
[4] Jour. Phys. Chem. 21, 1917, p. 386
[5] Phil. Mag. 33, 1917, p. 452.

Sources.

There are many sources of ultraviolet energy but few are powerful enough to be widely useful. The ideal source, which emits a continuous non-banded spectrum of high intensity throughout the entire ultraviolet region, does not exist.

The incandescent solids such as the latest Mazda lamps emit a continuous spectrum of appreciable intensity through only a part of the near ultraviolet region. The sun emits a continuous spectrum of fair intensity as far as 295μμ but this spectrum has many dark lines due chiefly to selective absorption by the sun's atmosphere.

The limelight and burning magnesium ribbon emit appreciable ultraviolet energy but not in sufficient amounts to offset the inconvenience attending their use. Of the present-day sources this leaves only the arcs, sparks, and vacuum tubes available for the more general work.

The mercury arc in glass is obviously limited in usefulness by the absorption of the glass. Consequently the mercury arc in quartz tubes is much more applicable to ultraviolet work. This arc has the great advantage of steadiness but the disadvantage in some cases of large gaps in its line spectrum. Investigation has shown that the output of ultraviolet energy decreases materially with the time that the arc has been used, some old quartz mercury arcs being only half as effective as they were when new. However for many problems this arc is very satisfactory.

The ordinary carbon arc emits a considerable quantity of ultraviolet rays in the near and middle regions but there are other arcs which are far superior to it and are no less convenient to use. The magnetite arc has a positive pole of copper and a negative pole consisting of a sheet steel tube packed with a fine powder consisting principally of oxides of iron (magnetite), titanium, and chromium. This arc is fairly rich in ultraviolet rays.

Measured from the standpoint of total ultraviolet energy per unit of visual intensity of illumination, Bell[6] ranks these sources in the following order: magnetite arc, old mercury arc, new mercury arc, and car-

[6] Elec. World, Apr. 13, 1912

bon arc, the last two being about equal on this basis and more than twice as rich in ultraviolet rays as the first two. This basis is of interest in lighting but it should be noted that, in general, the ultraviolet output per watt of energy input is generally of interest.

Some spectra of interest will be found in Reference 3 and many emission spectra are to be found in the Atlas of Emission Spectra by Hagenbach and Konen. Atlases of absorption spectra have been prepared by Uhler and Wood and by Mees which show the absorption spectra of many soluble coloring media.

Lyman[1] has shown that the mercury arc emits a strong line near 185$\mu\mu$ which will be very effective, in some reactions, with a short air-path but only feeble with a long air-path owing to the absorption by the air. This indicates that, when dealing with radiation of such short wave-lengths, very different results may be obtained with the same source depending upon the distance of the reaction from the source.

The flame arc has potential possibilities as a source of ultraviolet rays owing to the diversity of materials with which the carbons may be impregnated. It has been found that the feebly luminous flame of the ordinary carbon arc is the source of much of the short-wave ultraviolet energy emitted. The white-flame arc of high amperage, in proportion to the energy input, is the most efficient commercial source of near and middle ultraviolet energy available at present. It radiates energy quite extensively in the near and middle regions. Mott found the fading effect on dyes at a distance of 10 inches from a 28-ampere white-flame arc to be several times greater than June sunlight and that the fading results were approximately the same. Obviously there should be no rays present of shorter wave-length than 295$\mu\mu$ in a dye-testing illuminant if the results are to be comparable with that of sunlight. Such a source as the white flame arc could be screened by a thin glass shell of a proper spectral transparency in order to eliminate rays of those wave-lengths not found in daylight.

The blue flame arc emits ultraviolet energy very strongly.

It is a simple matter to construct an arc which will emit ultraviolet energy strongly, provided hand-control is satisfactory. An iron rod and a carbon rod may be employed successfully for the two poles, however, two iron rods may answer the purpose very well. These poles may be kept cool effectively by means of heavy brass or copper sleeves which may be moved along the iron rods as the latter are consumed. A particularly successful iron arc of this type can be made in a few hours. The upper pole, which is negative, may be an iron rod about ¼-in. in diameter. This is surrounded by a movable but well-fitted solid sleeve of copper about one inch in diameter. The lower pole may be an iron rod about ½-inch in diameter with the end in the form of a shallow dish. One pole should be adjustable vertically. In preparing the arc a bead of molten metal is developed in the dished end of the lower electrode, the latter becoming oxidized, which apparently decreases the rapidity of deterioration. The upper electrode is well cooled and the arc is maintained very steadily between the molten bead of iron and the upper solid electrode. The writer has had such an arc operate at a rather high current density for thirty minutes without any adjustment. The dimensions may be increased to meet the requirements. It is not a difficult matter to make various simple arcs which are quite satisfactory for a great deal of work.

For many purposes the spark between metallic electrodes is very satisfactory but, in general, the sparks can not compete with the arcs in quantity of ultraviolet energy emitted. Various forms of spark gaps have been employed depending upon the requirements; usually steadiness of position of the spark and shadows of the poles are the factors which determine the shape of the gap. A short spark obtained from a transformer may be satisfactory or it may be fattened by using a condenser. A high frequency spark may sometimes be desirable. The kind of spark obtained depends upon dimensions and electrical relations and obviously these may be widely varied. The metals commonly employed for the poles of spark gaps are aluminium, zinc, iron, copper, and cadmium, although any other may be satisfactory, depending upon its spectrum and upon the specific requirements.

The spectra of electrically excited gases confined at low pressures in transparent tubes have been extensively studied but such vacuum discharge tubes have found little or no use in industrial processes. They have provided sources of extreme value in some investigations. The spectrum of hydrogen under these conditions exhibits many lines and bands in the Schumann region. These tubes are usually of the capillary type and contain the gas at low pressures of the order of magnitude of one mm. of mercury. Obviously, in order to be useful in the extreme short-wave region, they must be provided with a fluorite window.

Lyman[8] has studied the spectra of various gases in the Schumann region. It is interesting to note that the character of the circuit and discharge influences the spectra of some gases very much. For example, argon yields no lines shorter than 190$\mu\mu$ in wave-length with no capacity in the circuit. By using a disruptive discharge a considerable number of lines appear throughout the Schumann region.

Properties.

The effects of ultraviolet energy are too numerous to discuss at length in this article but a few will be noted briefly. The chemical changes in silver salts are well known and have formed the basis of the extensive developments of photography. Draper enunciated a law for photo-chemical reactions which states that only the light absorbed is chemically active. The converse of this law—that every substance which absorbs light undergoes chemical change—apparently is not true. An aqueous solution of an inorganic salt, for example, $CuSO_4$, strongly absorbs yellow and red rays but is not altered chemically by these rays. Bichromate salts which absorb blue, violet, and ultraviolet rays are stable by themselves but in the presence of organic substances the bichromate is reduced, that is, photo-chemical action obtains.

Ultraviolet energy is in general superior to visible rays in the production of fluorescence and phosphorescence. In fact under powerful ultraviolet rays it is almost impossible to find substances which do not fluor-

[1] W. R. Mott, Amer. Electrochem. Soc., 1915. Mott and Bedford, Jour. Ind. and Eng. Chem. 8, 1916, 1029.

[8] Astrophys. Jour. 3, 1911, p. 98.

esce to a slight degree at least. One of the most interesting experiments is found in focussing an intense ultraviolet spectrum in a horizontal position in space and bringing various substances in this plane. In this position the surfaces of solutions such as aniline dyes may be brought into the focussed spectrum. It is very interesting to note the rays which are most effective. In the case of phosphorescent materials, the regions which cause fluorescence alone may readily be distinguished from those which produce the more permanent glow. Even different colors of the resulting luminescence may be distinguished at different spectral regions of the exciting radiation. According to Sheppard, all organic bodies possessing strongly marked absorption bands in the ultraviolet, seem capable of either fluorescence in a dispersed condition or phosphorescence in a condensed condition when excited by ultraviolet energy of a proper frequency or wave-length. There have been applications of luminescent analysis to mineralogical and botanical research. This entire field of phosphorescence and fluorescence offers many opportunities for pioneer investigations.

When polished metals, such as zinc, are illuminated by ultraviolet energy they become positively charged if insulated. If negatively charged they become discharged. Under the influence of the rays, negative electrons are discharged from the metal. The breakdown voltage of an air-gap is decreased when illuminated by ultraviolet rays. Some of these phenomena may be accounted for by the ionization of the air but many metals emit electrons under certain conditions when illuminated by ultraviolet light of sufficient intensity. This latter effect is known as the photo-electric phenomenon. Even the dust particles in the air exhibit this photo-electric effect. The alkali metals are especially sensitive in this manner to visible rays as well as to ultraviolet rays. The photo-electric cell has become a valuable measuring instrument for those rays to which it is sensitive.

Ultraviolet energy is of interest from the standpoint of the permanency of coloring media because it is especially destructive in this respect.

Lithopone is darkened by these rays as is easily seen by projecting an intense ultraviolet spectrum upon a lithopone surface. By using quartz lenses and projecting the image of an arc on such a surface, the darkening was perceptible almost instantly, although it required many minutes of summer sunlight to cause the same darkening. This is a simple method of obtaining an intense concentration of ultraviolet energy which is useful in many processes and tests.

Ultraviolet energy accelerates the chlorination of natural gas in the manufacture of chloroform and hastens other processes. Blue and violet light are also effective in causing or hastening many chemical reactions.

Short-wave energy even in the near ultraviolet region is effective in changing the color of glasses especially those containing manganese. Under the influence of the radiation from the mercury arc some of these clear glasses containing manganese will assume a purplish tint after a few hours of exposure.

Ozone is readily produced in the vicinity of a powerful source of ultraviolet. It is believed by some that the solar spectrum ends at about 295$\mu\mu$ on the short-wave end, due largely to ozone which absorbs maximally at 255$\mu\mu$. Of course, smoke and various gases play some part.

Pure water is quite transparent to the near and middle regions but tap water is ordinarily slightly absorbing. Pidduck[8] studied very dilute solutions of salts commonly found in tap water and found distinctly different transparencies for ultraviolet although the absorption was not very great in any case.

The ionization of air by ultraviolet rays has led some to believe that the electrons or ions provide nuclei for the condensation of water vapor and thus ultraviolet energy may play a part in rainfall. Dust particles may very well serve as nuclei, and in this connection the classic experiment of artificial production of clouds by providing various kinds of nuclei is interesting.

Ultraviolet energy is very powerful as a bactericidal agent, the disinfecting property of sunlight being one of the first principles of hygiene and sanitation. Consecutive days of rain, mist or fog permit the growth and development of pathogenic organisms.

Owing to the transparency of water to the ultraviolet rays emitted by the quartz mercury arc, the latter is in use for killing germs in water. The water is usually filtered if it contains much solid matter in order that germs may not escape death in the shadow of a suspended particle.

Some medical authorities believe that ultraviolet rays are of greater value as a curative or bactericidal agent when associated with the blue and violet rays or even with the whole spectrum.

The effect of ultraviolet energy upon animal tissue is indicated by the bronzing of the skin and especially by the destructive effect upon the membranes of the outer eye. The cornea is opaque to all rays of shorter wave-lengths than about 295$\mu\mu$, therefore none but the near ultraviolet rays can reach the retina. But the lens is not transparent as far into the ultraviolet as the cornea. Owing to the industrial processes, such as acetylene and arc welding, which are attended by powerful ultraviolet energy, there is a demand for eye-protecting glasses. To develop such glass and to test the finished product, spectroscopy of the ultraviolet is necessary. Visual inspection cannot be depended upon for determining the satisfactoriness of eye-glasses in absorbing the ultraviolet rays.[9]

Measurement

Although much valuable information can be obtained by qualitative experiments, ofttimes it is necessary to measure at least the relative amounts of ultraviolet energy. There are many methods available; in fact, many of the properties of ultraviolet rays may be employed in measuring the intensity of the invisible energy provided a relation between effect and intensity is established.

The photographic plate is perhaps more generally used than any other method. Relations between intensity of the radiation, exposure, and photographic action or plate density must be established for the radiation to be measured. Owing to the opacity of gelatine in the Schumann region it must be eliminated

[8] Phil. Mag. 17, 1909, p. 710.
[9] Luckiesh, Trans. Illum. Eng. Soc. 9, 1914, 472

or greatly reduced in amount if this region is to be investigated photographically. Schumann adopted a special process of making silver bromide emulsions very weak in gelatine. His plates were sensitive to the short-wave region but not to radiant energy of longer wave-lengths than 300μμ. The photographic plate is perhaps the only means used for detecting ultraviolet energy of the shortest wave-lengths.

For certain regions the electroscope has been employed because of the leakage of its charge when connected to a piece of clean zinc which is illuminated by ultraviolet energy.

The photo-electric cell is sufficiently sensitive for spectral analysis in the near and middle regions but the relation between current and intensity of radiation must be established for the cell used. When cells are made according to certain specifications this relation has been found to be linear.

If the ultraviolet energy is sufficiently intense its heating effect may be used as a basis of measurement. In such a case the bolometer, radiomicrometer, and thermopile may possibly be sufficiently sensitive under the best experimental conditions.

Owing to the large number of photo-sensitive reactions it is possible to devise various methods of measuring ultraviolet energy, at least relatively, for certain ranges of the spectrum depending upon the reaction chosen. These are too numerous to be discussed at length here.

It has been the aim to review the subject in general as it might interest the chemist. In doing this within the limits of a single article it has been impossible to discuss many aspects and excellent researches; however, in the few references given will be found many others which will aid those who wish to pursue the subject further.

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Problems of Wage Payment

By H. N. STRONCK

ONE of the most serious problems which industry is facing to-day is the problem of labor. Never before in the recent history of this country has there been such a scarcity of labor of all kinds, both skilled and unskilled. There is no outlook at the present time for an increase in the total number of labor units in this country, but there is every possibility that the scarcity will become greater and greater as time goes on and greater demands are made on the labor supply for Government service. The rate of wages in most industries is from 20 to 60 per cent greater than during the pre-war period and the effectiveness of labor at these much higher prices is far less than it was two or three years ago. To make matters worse, certain types of industries are able to give a much higher proportionate increase in wages than other concerns not so fortunately situated. As a result very keen competition has arisen in obtaining and holding labor of all classes from the highly skilled to the most ordinary type.

Objects to Be Attained

The majority of industrial managers are aware of this situation and can see far enough into the future to realize that some very strenuous efforts must be made to stabilize these conditions, to meet the ever increasing wage scale and to obtain a labor turnover as small as possible. The problem resolves itself into three parts:

(A) To hold the present working force intact.

(B) To be able to obtain and hold additional workers.

(C) To establish intensive training and co-operative methods so as to obtain the highest possible effectiveness of each labor unit.

Recent Plans

In order to hold the present working forces intact three general plans have come into vogue during the past year:

(A) The payment of a so-called service bonus.

(B) Insurance policies for workers.

(C) Betterment of working and housing conditions.

Service bonuses are generally paid as a percentage of the present wages, and vary with the length of continuous service. A very popular one is the payment of a 10 per cent bonus at the end of every three months for continuous service during the period. Other popular ones are based on a sliding scale of 5 per cent for three months' service, 7 per cent for six months' service and 10 per cent for one year's service. The contention is that the average worker employed in such an industry will at least remain the full length of the service period. In some industries the majority of the departments are on some type of production payment plan, and in such departments or groups where conditions are such that a production plan cannot be introduced a service bonus is paid above the nominal wage scale in order to equalize the wages throughout the plant. Service bonuses have a good effect on the older employees and especially on such employees who have their homes established in that community. Service bonuses, however, do not have a very great effect on obtaining new labor especially of the nomadic class, who are easily influenced to shift when they find that higher base wages are paid in their line of occupation in other plants, even though these plants be located at some distance from the community. Service bonuses as a rule do not act as an incentive for increasing production, and hence one of the greatest objects to be desired is not attained.

Life insurance policies for workers have become very popular during the past year. The amount of insurance taken out for a worker and paid for by the company is usually based on the yearly wage of the employee and the number of years of previous service in the plant. This form of reward acts well on the older and more settled employees who have families or de-

pendents, but has practically no effect on new labor or on younger employees with no dependents. Insurance rewards do not act as a strong incentive or argument in the obtainment of new labor units.

With the advent of the dilution of male labor with female it has become necessary to arrange for far better working conditions. Otherwise no very strong bid can be made for obtaining and holding female employees for ordinary plant operations. The general effect of improving working conditions is very good. It eliminates certain frictions and grievances and the general tone of the plant is raised to a higher level.

Production Rewards

The desired result in all industries is to:

(A) Obtain maximum production from each unit of labor.

(B) Pay higher wages than those paid in competing labor markets.

(C) Have the lowest possible direct labor cost per unit of production.

(D) Keep wastes of material at a minimum.

(E) Have all methods work toward the ultimate benefit of both employer and employee.

The advent of systematic cost-accounting methods must be credited as being one of the most important influencing factors for the introduction of wage payment plans based on production and waste elimination. Cost-accounting methods analyze and bring to the attention of the management true present costs and abnormal conditions of cost. Knowing the present cost, it then becomes the desire to reduce these. As a result a great many methods, plans and schemes have been evolved and introduced for the attainment of this object.

The management soon realized that the most wasteful and ineffective method of wage payment was the day-work method. Therefore, day-work methods must be replaced by methods which are based on reward for effort expended. The chief difficulty encountered was in the design of some plan whereby the effort of practically all employees could be measured and the reward paid accordingly.

Profit-sharing plans were introduced as far back as 1842, had a good effect in certain instances, but in general did not attain the object desired because they did not include certain fundamental principles necessary for success.

Essential Points of Wage Systems

Any system of reward to be highly effective must have the following points:

(A) The reward must be a definite and positive gain to the individual.

(B) The reward must be definitely known before the work is commenced.

(C) The reward must be personal; that is, the reward must be for that particular person, for that particular work.

(D) The individual must get exactly what was determined before.

(E) The individual must be positively assured that he will get the reward.

(F) As soon as the work is done the individual must get the reward.

Piece Work

Piece work, which was the most popular method until the efficiency movement reached its height, met the majority of these points. There is nothing wrong with the piece-work system in itself, but so many violations have taken place in the fundamental principles that the objects to be desired were not reached. Considerable dissatisfaction, grievances and many strikes have taken place. Piece-work methods are looked upon with great suspicion by the working classes. Regardless of whether or not piece prices have been cut in any particular plant, the inherent suspicion against piece work still remains in the minds of the workers, and one of the greatest of industrial wastes, the limitation of output, has been the result. With the present great fluctuations in labor market conditions it would hardly be advisable to introduce the very inflexible piece-work schemes. When it becomes necessary to pay higher wages, piece prices must be raised. If labor prices should decline, the only way the management could take advantage of this would be to reduce the piece prices. Also the principles of straight piece work do not guarantee a living wage. With the present ineffectiveness of labor and the introduction of female workers in industries, it becomes highly essential that, regardless of the output at the start, at least a guaranteed wage must be paid in balance with the daily wage scale in that district. From the standpoint of the management a piece price definitely fixes the direct labor cost per unit and there is no way of reducing the labor cost with high production unless the piece prices are cut.

Bonus Plan

Since the desired object was not attained by the piece-work, profit-sharing, contract methods, etc., new methods have come into vogue, many of which have been very successful and have replaced the plans previously referred to.

Bonus systems in general are based on the principle of dividing the savings effected in some definite proportion between the management and the employees. The majority of these guarantee an hourly wage, specify some definite standard of output and pay a bonus, in some cases when this standard is reached, and in a good many others when this standard is exceeded. The accompanying Chart I compares various forms of the best known and the most popular wage-payment plans.

Comparison of Various Methods

In making this comparison certain assumptions were necessary due to the fact that different standards must be set for each type of plan in order to produce the same amount of remuneration for the same output at a certain point. In determining standards for any type of production wage-payment plan the two following questions must be answered:

(A) How much work can be performed by a first-class worker at a speed under which he will thrive?

(B) What extra inducement must be paid to this first-class worker for this output?

On the particular case in point it was found by a long series of experiments and by time and motion study that a first-class worker could produce 148 units of output per hour and deliver this output day after day and month after month without injury to himself. It was

also found that a reward of 30 per cent above the wage scale was necessary to induce the worker to produce this output. The normal wage scale on this operation was 20c. per hour. Therefore, for an output of 148 units per hour it became necessary to pay a bonus of 6c. per hour, or a new rate of 26c. per hour. Regardless of the wage-payment plan, this worker must receive 26c. per hour for an output of 148 units per hour. All curves must intersect at point "Q."

HALSEY 33⅓ PER CENT PREMIUM PLAN (WAGE LINE GH)

Under this plan the worker receives as a bonus one-third of the value of the time saved. Example: If a worker's rate is 20c. per hour, a standard of 10 hours is set on a job, and the worker performs this in 7 hours, thus saving 3 hours, he would receive as a bonus one hour's time.

Because of the small part of the value of time saved paid as a bonus, the standard under this plan would necessarily be very low. As shown on this chart the standard would be 57½ units per hour and at an output of 148 units per hour he would receive the 30 per cent extra inducement.

Owing to the fact that the workers' share of the savings is small, no great investigation is necessary to determine standards under this plan. In general under this plan the standards are estimated from previous costs, and as a worker reduces these costs he receives one-third of the savings.

HALSEY 50 PER CENT PLAN (WAGE LINE FL)

Under this plan the worker receives as a bonus one-half of the value of the time saved. Example: If a standard of ten hours is set on a job and the worker performed this in seven hours, thus saving three hours, he would receive as a bonus 1½ hours' time.

Because there is a larger part of the value of the time saved paid as a bonus to the worker under this plan than under the Halsey 33⅓ per cent, the standard set would need to be greater Referring to the chart it will be seen that the standard under this plan would need to be 88 units per hour to bring the intersection at point "Q."

A greater intensive study of conditions and outputs must be made under this plan than under the Halsey 33⅓ per cent. In a great many cases the standards under this plan are based on time study, while in many others they are based on previous estimates of cost, and as a worker reduces these costs he receives one-half of the savings.

THE TAYLOR SYSTEM (WAGE LINE RQN)

Under the Taylor system two piece prices are set, known as the low rate and the high rate. Under this comparison the high rate is 30 per cent greater than the low rate. The standard set would be 148 units of output per hour. For outputs less than this amount the piece price would be 20 per cent less than for an output of 148 units per hour or more. Under this system the reward is great when the standard is reached, but for a failure to reach this standard the penalty is severe. Under this plan only a first-class worker can reach standard and thus obtain the bonus. Under present industrial conditions of ineffectiveness of labor units but very few workers in the ordinary plant would be able to reach the high reward under this plan. If it were possible to fill a plant at the present time with first-class workers this method of payment would act as the strongest possible form of incentive, but it would be far too difficult to introduce under present industrial conditions. Less than 10 per cent of the workers in the ordinary establishment would be able to take advantage of the high reward offered. Under this system great precision in rate setting and utmost standardization of operations are necessary.

GANTT SYSTEM (WAGE LINE XRQN)

The Gantt standard is the same as the Taylor; that is, 148 units of output per hour. Under this plan, however, applied to the case in point, an hourly wage of 20c. would be guaranteed regardless of the output. If the output reached 148 units per hour a bonus of 30 per cent would be paid.

Under this system the penalty for not reaching the output of a first-class man is not so severe. All workers are at least guaranteed a standard wage. The standard under this system must be set very accurately and conditions must be highly standardized. Only first-class operators would receive a bonus and hence such a system would effect but a small proportion of the employees in a plant under present industrial conditions.

STRAIGHT PIECE WORK (WAGE LINE AN)

Under straight piece work a definite price per piece would be paid regardless of the output. Under the case in point the piece price would be 0.176c.; that is, for an output of 148 pieces 26c. would be paid. If the output were less than 114 pieces per hour the worker would receive less remuneration than under any of the plans where the hourly rate is guaranteed at 20c.

THE EMERSON EFFICIENCY SYSTEM (WAGE CURVE BP)

Under the Emerson system the standard would be 138 units. A bonus of 20 per cent is paid, and the worker would receive 24c. per hour. The Emerson bonus, however, commences at efficiencies of 66⅔ per cent, so that if the output exceeds 108 units per hour, some bonus is paid. The proportion of bonus paid takes the form of a parabola from the 66⅔ per cent point to the 100 per cent or standard point. After the 100 per cent point has been reached, in addition to the 20 per cent bonus at 100 per cent, an extra 1 per cent bonus for each 1 per cent of efficiency increase above 100 per cent is paid. Example: If the efficiency is 110 per cent the bonus is 30 per cent.

The Emerson system is one of the most modern developments of bonus systems, has been given wide publicity through the writings of Mr. Harrington Emerson and has been applied in a great number of plants.

The standard under the Emerson system must be set with considerable care, as under the Gantt and Taylor systems.

ROWAN DIMINISHING PREMIUM SYSTEM (WAGE LINE CK)

This illustrates a typical diminishing premium system whereby rates are automatically cut at higher outputs. As under the others, a standard time is set and the worker receives his hourly wages for the time actually engaged on the job plus a premium figured on the actual time in proportion to the time saved to the

standard time. The formula for calculation of wages is

$$\left(\text{Time taken} + \left\{\frac{\text{standard time—time taken}}{\text{standard time}}\right\} \times \text{time taken}\right) \times \text{hourly rate} = \text{Wages.}$$

Under this system the worker can never double his day wage, as the value of the controlling factor, which is

$$\frac{\text{Standard time—time taken}}{\text{Standard time}}$$

constantly approaches unity as the time consumed approaches zero. Hence, the premium can never exceed the day rate multiplied by unity. Under this system the workman soon learns that above a certain output the reward is not sufficient to warrant the extra effort on his part. Because of this, limitation of output is very frequent under this system. This system has been in use in a number of plants, but because of its many disadvantages was discontinued and replaced by more equitable plans.

There have been various modifications of the original Rowan plan and in many the decrease in price per piece has been much more rapid. By comparing diminishing premium plans with any equitable plan it will be noticed that a zone is formed between the diminishing premium curves and any of the curves of the equitable plans. Louis Ruthenburg of the Dayton Engineering Laboratories Co. (Delco), after an exhaustive study of a large number of payment plans, named this zone the "Zone of Deception."

Where this plan had been introduced the management had the feeling that it was impossible to set accurate standards and their fear was that workers would earn too high wages. With the advent of scientific rate setting by time and motion studies the danger of inaccurate standards has been eliminated so that there is no justification for introducing any diminishing premium plans.

As will be noticed from the chart, the standard set for the case illustrated would be 105 units of output per hour.

THE BENEDICT-STRONCK DIFFERENTIAL TIME BONUS SYSTEM. (WAGE CURVE EM ¼ PER CENT PRINCIPLE—WAGE CURVE DO ½ PER CENT PRINCIPLE)

In formulating the principles and designing the application of these systems the object in view was to include the strong features of other wage systems and eliminate as many as possible of the weak points. The results obtained in practice by these methods have proven that this object has been attained.

These systems are based on certain fundamental principles and the design of the curves vary for different conditions without violating the fundamental principles. The fundamental principles on which these are based are:

(A) Guaranteed hourly rate known as the "base rate" below which the worker does not fall.

(B) A time allowance for each job known as the "standard time."

(C) A division of the value of the time saved from this "standard time" between the worker and the management on an increasing differential basis, in favor of the worker; that is, the greater the output the greater will be the proportion of the value of the time saved given as a bonus to the worker.

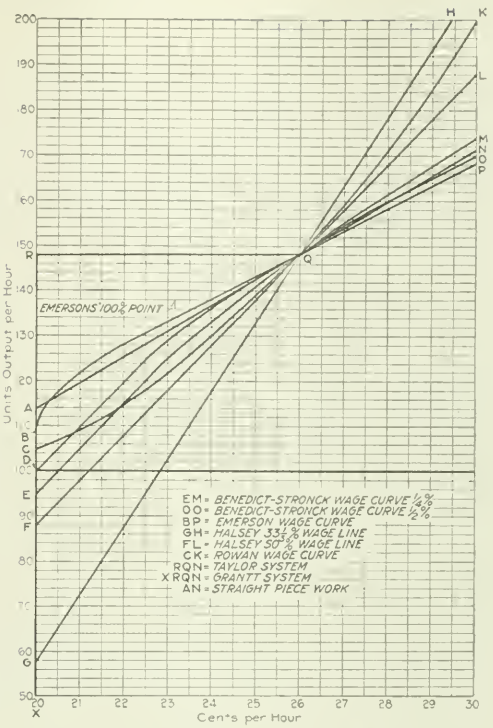

Units Output per Hour
Cents per Hour
EMERSONS 100% POINT
EM = BENEDICT-STRONCK WAGE CURVE ¼%
OO = BENEDICT-STRONCK WAGE CURVE ½%
BP = EMERSON WAGE CURVE
GH = HALSEY 33⅓% WAGE LINE
FL = HALSEY 50% WAGE LINE
CK = ROWAN WAGE CURVE
RQN = TAYLOR SYSTEM
XRQN = GRANTT SYSTEM
AN = STRAIGHT PIECE WORK

CHART 1. COMPARISON OF WAGE-PAYMENT PLAN

The accompanying Chart II illustrates the details of the Benedict-Stronck differential time bonus system on the ¼ per cent principle. This illustration is designed according to the following mathematical principles:

For efficiencies of between 100 and 125 per cent the worker receives as a bonus one-half of the value of the time saved. This is equivalent to the Halsey 50 per cent principle.

For efficiencies above 125 per cent the worker receives as a bonus, in addition to half the value of the time saved, ¼ per cent of the value of the time saved for each per cent of efficiency increase above 125 per cent.

As will be noted, the differential parabola is connected with the 50-50 line at the 125 per cent point. The following two examples illustrate the detailed calculation of the new hourly rates:

(A) For a point less than 125 per cent in efficiency. (Refer to curve ABD)

ASSUME: Standard time = 10 hours
Base rate = 20 cents
Efficiency = 115 per cent

$$\text{Then actual time of performance} = \frac{10.0}{1.15} = 8.70$$

hours.

10.0 — 8.7 = 1.3 hours of time saved.
Value of time saved = 1.3 × .20 = $0.26.
Bonus is one-half of this = $0.13.

WORKER'S PAY: On base rate = 8.7 × .20 = $1.74
Bonus = .13

Total pay for 8.7 hours work $1.87

$$\text{Hourly rate for job} = \frac{\$1.87}{8.7} = 21.5 \text{ cents.}$$

(B) For a point on the parabola or above 125 per cent of efficiency:

ASSUME: Standard time = 10 hours
Base rate = 20 cents
Efficiency = 165 per cent

$$\text{Then actual time of performance} = \frac{10.0}{1.65} = 6.06$$

hours.

10.0 — 6.06 = 3.94 hours of time saved.

Value of time saved = 3.94 × .20 = $0.788.

50-50 bonus is one-half of this = $0.394.

Increase in efficiency over 125 per cent = 165 — 125 = 40 per cent.

Additional bonus of one-fourth per cent of value of time saved for each per cent above 125 per cent $= \frac{40}{4}$ = 10 per cent additional = .10 × .788 = $0.079.

WORKERS' PAY: On base rate = 6.06 × .20 = $1.212
50-50 Bonus = 0.394
Differential bonus = 0.079

Total pay $1.685

$$\text{Hourly rate for job} = \frac{1.685}{6.06} = 27.8 \text{ cents.}$$

The following formula applies to the curve of the ¼ per cent principle.

New rate per hours = R
Base rate per hour = R_1
Standard time = T_1
Actual time = T_2

$$R = \frac{R_1}{4\,T_2^2}\,(T_1^2 - 0.25\,T_1\,T_2 + 3.25\,T_2^2)$$

By referring to the "per cent saving in direct labor above margin" (curve AHC) it will be noticed that the direct labor cost keeps on decreasing and the maximum saving to the company in direct labor is at 180 per cent of efficiency. The zone of the maximum saving in direct labor to the company lies between efficiencies of 165 and 195 per cent. At these points of maximum saving to the company the bonus to the worker is from 39 per cent to 64 per cent.

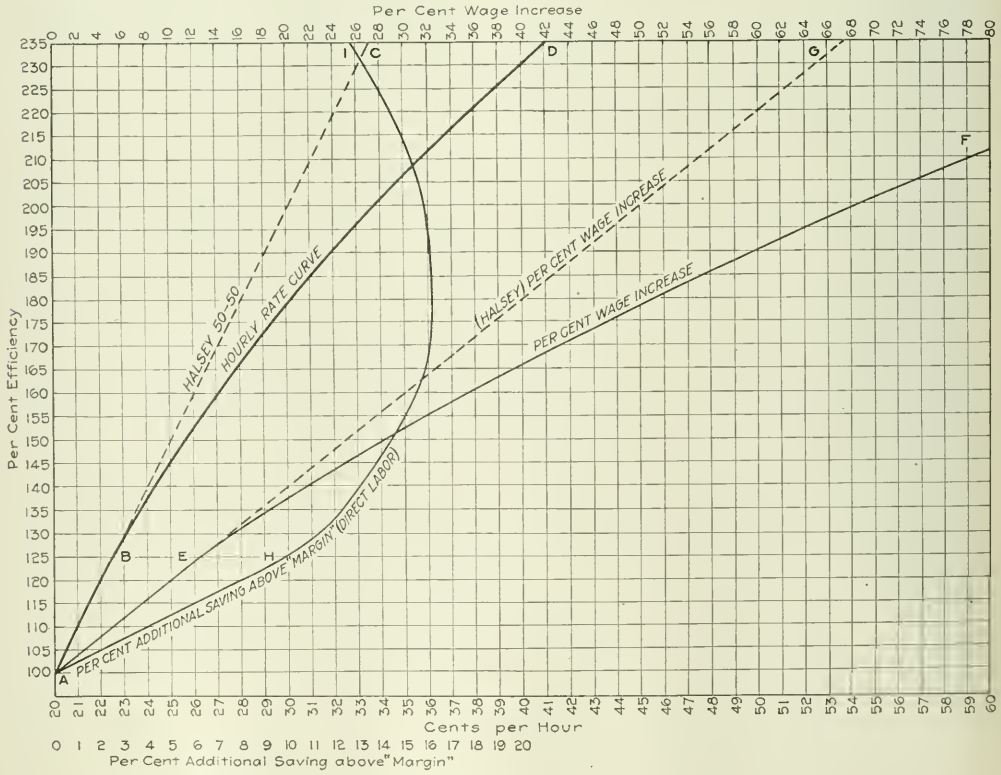


CHART II. THE BENEDICT-STRONCK DIFFERENTIAL TIME BONUS SYSTEM

Under this system, if it is assumed that a first class worker is to receive a 30 per cent extra inducement for working at his best, he would have to reach an approximate efficiency of 153 per cent.

The system under the ½ per cent principle, as illustrated by curve "DO" on the comparison chart, is identical to that of the ¼ per cent principle up to the 125 per cent efficiency point: that is,

(A) For efficiencies between 100 and 125 per cent the workers receive as a bonus ½ of the value of the time saved.

(B) For efficiencies above 125 per cent the worker receives as a bonus, in addition to half of the value of the time saved, ½ per cent of the value of the time saved for each per cent of efficiency increase above 125 per cent.

Since the relative proportion of savings given to the worker increases more rapidly under this than under the ¼ per cent principle, the worker would need only to reach an efficiency of 148 per cent to receive a 30 per cent bonus.

As will be noticed, these systems have a great flexibility of design without violating fundamental principles. The parabola may be attached to the Halsey 50-50 line at any point. The slope of the parabola may be increased or diminished by calculations other than the ¼ or ½ per cent principle, such as, a ¾ per cent or ⅓ per cent principle.

The differential feature of these systems acts as one of the most powerful of incentives. Workers strive to attain high efficiencies because their proportionate reward is so much greater. Every worker in a plant, who is industrious and fitted to his work, can earn at least some extra reward under these systems. Therefore, these systems have a strong appeal.

Application

The actual application of these systems in practice is very simple. From the curves, a table is computed which shows the per cent bonus at the various efficiencies. This per cent bonus is always a per cent of the base hourly wage.

A standard once set, under this system, need not be changed to meet fluctuations in the labor market. Every advantage of these fluctuations may be taken by fluctuating the hourly rate at which workers are engaged. This is one of the strong points of this system and, hence, has become very popular in replacing inflexible methods.

In practice a standard time, or standard output, is very carefully determined by means of motion studies, time studies, and fatigue studies, taking into consideration all economic, psychological and sociological factors entering into the problem.

Efficiency is determined in either of two ways:

$$\text{(A)}\quad \frac{\text{Standard time}}{\text{Actual time}} = \text{Efficiency per cent.}$$

$$\text{(B)}\quad \frac{\text{Actual output}}{\text{Standard output}} = \text{Efficiency per cent.}$$

By-Products

There are many very valuable by-products of these bonus systems:

(A) The standard time gives precise information as to outputs of various operations and, hence, is invaluable in determining plant capacities and the layout of scheduling methods.

(B) The standard times also give standard costs of labor which are of great value for cost accounting and estimating purposes.

(C) A direct comparison can be made of the personal effectiveness of each labor unit regardless of the kind of operation.

(D) Weak points in personnel are easily determined and brought to the attention of the proper official, so that proper remedies can be applied consisting generally of more intensive training or shifting to operations for which the worker is better adapted mentally and physically. The writer has come in contact with many cases where certain employees on the work at which they are employed could make but 60 per cent efficiency. After three or four shifts had been made to different operations, the worker was finally assigned to some operation on which he could reach from 160 to 180 per cent efficiency simply because he had ideal mental and physical qualifications for the operation selected.

Due to the flexibility of these bonus systems a far greater percentage of the workers can be placed on a reward basis than under piece work or many other plans. Practically all employees engaged in and about plants can be placed on some form of reward in proportion to their efforts expended.

Waste Elimination Bonus

In general, as production is increased the tendency is towards a decrease in quality. To overcome this, one of the strongest features is the introduction of a waste elimination bonus. These are based on identical principles as those of the production bonus; that is, a standard quality or amount of waste is set and as the quality is increased above this standard or waste decreased below this standard an extra bonus is paid. Also a very thorough training and inspection system helps greatly to increase quality. The writer has found in general that where the installation has been carefully made, quality is increased rather than diminished and in many instances there have been enormous savings in waste elimination alone.

The Design of Bonus Systems to Meet Certain Conditions

By keeping well in mind the objects to be attained and the fundamental principles involved, equitable bonus systems can be designed to meet almost any conditions.

Recently the manager of a large and prominent plant was face to face with a very serious labor problem. This plant was in a very much better condition than most plants of its kind. This executive had a far greater knowledge of the principles and practices of scientific management than the average executive. It was absolutely essential that production be considerably increased. Due to the extreme scarcity of labor the best possible method for increasing the production was by increasing the effectiveness of the present labor forces. It was realized that the strongest possible method would be the introduction of some incentive form of wage payment. The entire plant had

been on a day work basis since its conception. The attitude of the employees had always been strongly against anything but day work and the chief problem was to submit to them some form of wage payment plan which would be acceptable to them and to which they would give their full and hearty co-operation. After a thorough study of the conditions, in all their various phases, the writer designed and introduced a bonus system which met with the hearty approval of the employees. As a result, the average production of such operations on which the method has been applied to date has increased approximately 65 per cent. The average wage to employees under the bonus plan has been increased from 25 to 30 per cent. The object has been attained. The management profited by the tremendous increase in production and the decrease in labor costs and the employees by a considerable increase in their earnings.

Actual practice has shown that the differential time bonus system is far superior to piece work. A certain plant had been on piece work for years. On analyzing the operations it was found that the evil of limitation of output existed. The piece work system was replaced by a differential time bonus system and a very marked increase in production was effected throughout this plant.

Determination of Standards

The success of any payment plan of this kind rests upon the accuracy and equitableness of the standard times. By applying modern methods of motion and time study and a thorough study of the fatigue problem equitable standards can be set. Such standards, however, should not be set by untrained persons but under the guidance of experts, thoroughly familiar with analysis, fatigue, and such economic, psychological and sociological factors as have a bearing on the attitude of labor.

Working Hours

In most industries, the tendency now appears to be toward the eight-hour day. Statements have been made at various times that the same output could be obtained by reducing from a ten-hour to an eight-hour basis. These statements may have been true in certain cases, but in general this is not the case. Any given plant, however, operating under a ten-hour basis under day work or a wrong wage payment plan can be made to produce as much, and even more, in eight hours than in ten hours by a more thorough analysis and standardization of operations, better training of workers, improved scheduling methods, and the introduction of the best possible type of bonus system.

In many industrial districts, especially in such plants working on war supply contracts, the eight-hour day is in effect, but in the majority of cases the workers actually are employed ten hours and receive time and one-half for overtime over eight hours. This appears to be the popular trend today.

The Dilution of Male Labor with Female Labor

Owing to the great scarcity of labor it has become absolutely essential to employ women in industry. In order to be successful in this undertaking, far better methods of all kinds must be applied. The problem of intensive training and supervision becomes greater. There are numerous operations in almost every plant which can be performed by women and by proper selection, training, and supervision and by improving working conditions, in the course of time the outputs on such operations will be just as great, if not greater, than under former male labor.

Conclusion

In conclusion, it must be stated that even the best and most approved wage payment plan is not a cure for all ailments. It is absolutely essential, and a patriotic duty to every industrial organization to see that the greatest possible production with the least waste and cost is obtained. An ideal bonus system may have no effect whatsoever, or a disastrous effect, in case it is wrongly applied. Owing to the tremendous importance of the problem and the effect of such methods, it is the duty of every executive contemplating the introduction of such plans to see that:

(A) The design of the method is absolutely correct and does not violate fundamental principles.

(B) That the plan be correctly introduced.

Where this is done the objects will be attained and the results will be to the ultimate benefit of both employer and employee, which is the acid test of any method or plan.

Chicago, Ill.

Foreign Trade Convention Postponed.—The Executive Committee of the National Foreign Trade Council announces that "owing to the railroad congestion and the desire of the council to co-operate with the Government in the relief of the situation due to the war," the dates of the Fifth National Foreign Trade Convention to be held at Cincinnati, Ohio, have been changed from Feb. 7, 8 and 9 to April 18, 19 and 20, 1918. Merchants and manufacturers who are desirous of receiving invitations to attend the convention at Cincinnati are requested to send their names and addresses to O. K. Davis, Secretary National Foreign Trade Council, 1 Hanover Square, New York City.

Tariff Committee of Dyestuffs Association.—The Committee on Organization has appointed the following Tariff Committee: Dr. J. Merritt Matthews, chairman; August Merz of Heller & Merz; R. T. Dicks of Dicks, David & Co., and H. G. McKerrow of E. F. Drew & Co., all of New York; L. A. Ault of Ault & Wiborg Company of Cincinnati, and C. S. Althouse of the Althouse Chemical Company of Reading, Pa. The committee held a meeting on Feb. 11, at which the final proposals to be submitted to the Tariff Commission were gone over. It will hold another session in Washington immediately before conferring with the Commission. This committee has formulated definite ideas as to what the tariff regulations should be in order to safeguard the industry and has also determined upon what is considered a just and fair schedule of tariff rates. These are being withheld for the present by the committee, pending two conferences which that body has arranged to hold with the United States Tariff Commission in Washington.

It is expected that this committee's report will be in such shape that it may be included in the report of the main committee to the meeting of the main body of the newly organized association on March 6 at the Chemists' Club in this city.

The Vulcanization of Rubber

By ANDREW H. KING

THE whole structure of rubber products rests upon one important discovery—vulcanization. In 1839 Goodyear of New Haven, Conn., found that rubber, when mixed with sulphur and heated, underwent a "change." That is, that its physical properties were decidedly altered. It now had a much greater stability toward temperature changes, and showed a large increase in tensile strength and elasticity. This was the principal and basic discovery, and is used in nearly all the rubber shops the world over. The cold process of vulcanization by the use of a dilute solution of sulphur chloride, S_2Cl_2, was developed by Alexander Parkes in 1846. There is no question as to the relative importance of the two discoveries. The cold process finds application only with extremely thin pieces of rubber, such as toy balloons, etc., and some kinds of spread goods.

Regardless of the manner in which it comes about, vulcanization is similar to the hardening or coagulation of a gel. A typical example of such a change is the behavior of glue with tannin. It requires no great stretch of the imagination to compare it with the setting of a custard pie or the baking of a fruit cake. The fruit cake idea is of particular value in that it gives us a simple homely parallel which will serve to make the mystery of compounding and vulcanization a little more understandable.

In preparing a cake the first concern of the cook is to produce a colloidal suspension, a batter consisting of milk, flour and eggs. To this are added the sugar, fruit, flavoring, baking powder, etc. When completed it is in the form of a not too stiff dough. It is then poured into pans and baked. The heat sets or coagulates the gel. That it happens also to liberate a gas which brings about porosity does not alter the similarity. In fact, in preparing sponge rubber the rubber chemist also resorts to this trick. The pastry cook must understand the preparation of the gel. He must know how to produce the properties of taste, flavor, etc., which make a cake so desirable to mankind. Compounding is not greatly different. It is the art of mixing various materials with rubber which give to it, subsequent to vulcanization, certain desirable physical properties.

The first step in the preparation of a stock is to break down the rubber. This is accomplished on a mill which consists essentially of two large horizontal rolls which rotate toward one another. To break down the rubber is, as is implied, to render it soft and plastic like a dough. When this condition is reached the various compounding ingredients are added. The plastic rubber takes them up in much the same way as bread dough takes up more flour. The rubber behaves as a super-cooled liquid and a stock is no more nor less than a solid solution. That the solid fillers are not added in lumps like chopped fruit to a cake but in very fine powders is due only to the fact that more desirable physical properties are obtained thereby. The unvulcanized stock is a highly plastic mass with but very little elasticity or strength. Vulcanization reverses the situation, after which we find it strong and elastic with but very little of the original plasticity remaining. The effect of the individual fillers will be discussed in a later paper, but it will suffice here to say that their general effect is to decrease the stretch and to increase the tensile strength, hardness, toughness, and resistance of the stock to wear. This effect is not in direct proportion to the volumes involved, for some fillers give a greater increase and some a less. For example, if equal volumes of gas black and barytes be added to rubber in two separate but otherwise similar batches, the one containing the black will show a higher tensile strength and a relatively lower stretch, while that containing the barytes will show a lower strength and a higher stretch. This difference in behavior may be due to a number of things but is thought to be fundamentally a phenomenon of adsorption.

The above gives a general idea of the usefulness of vulcanization. We will now go on the various theories which have been advanced from time to time, as explanations of the mechanism by which it occurs. These theories are all of them incomplete and imperfect. But poor as they are they afford us a vehicle of thought and their proof or disproof advances our knowledge of the subject.

Chemical Theory

Carl Otto Weber was the first to investigate the chemistry of vulcanization. He divided the sulphur of a mixing, subsequent to heating, into two classes—free and combined. The first was removable by solvents, acetone being most satisfactory. The second, combined sulphur, he was never able to eliminate. In fact, no one with the possible exception of Spence, has ever been able to do it either. He found that rubber containing less than 2 to 2½ per cent combined sulphur did not show completely the physical characteristics of a properly vulcanized stock. First evidence of the "change" is seen when the combined sulphur is about 1.25 per cent. The physical properties become better and better until 2 to 2½ per cent combined sulphur is reached. He therefore concluded that this amount of combined sulphur was necessary to produce the first of a series of compounds which he called polyprene sulphides, the empirical formula of which he thought to be $(C_{10}H_{16})_{10}S$ which indicates 2.3 per cent combined sulphur. By using larger amounts of sulphur and a longer period of heating he obtained, just as did Goodyear before him, a hard substance, an ebonite, which contained approximately 32 per cent of combined sulphur. Try as he might he was unable to produce an ebonite with more than this amount of combined sulphur. This would indicate a compound of the formula $C_{10}H_{16}S_3$ or better $C_{100}H_{160}S_{30}$, which he concluded to be the highest member of his series of polyprene sulphides. As evidence which would tend to prove the existence of the intermediate members of the series, he recorded that the relation of combined sulphur to time, tempera-

ture being held constant, was not a linear function but that certain breaks were noticeable in the curve. Each break he thought indicated a new polyprene sulphide. Axelrod thought somewhat differently of the matter. He considered, and rightly, that heat has two effects on rubber, first to make it soft, plastic and tacky, to depolymerize it; and second to bring about the combination with sulphur. The breaks in the curve he concluded showed depolymerization, followed by further addition of sulphur. He did not seek to overthrow Weber's theory but only to supplement it. Now it happened that Weber heated mixtures of sulphur and rubber (9.1 per cent sulphur) in an autoclave at fixed temperatures between 120 deg. C. and 130 deg. C. Samples were withdrawn every hour or half hour and their combined sulphur determined. It is not surprising in view of such faulty technique that the curve contained several sharp bends. Every time the autoclave was opened to remove one piece the other pieces were undoubtedly cooled off. No one has ever isolated these intermediate polyprene sulphides, which fact gave Wolfgang Ostwald a point in favor of the adsorption theory. The investigation was at a standstill for a number of years until Spence, seeking to prove the adsorption theory, heated different samples of a mixture of rubber with 37 per cent sulphur for varying lengths of time. His combined sulphur curve showed a regular increase with time from zero up to 31.97 per cent. There were no breaks nor bends in his curve whatever. He did show, however, that the removal of the free sulphur gave typical adsorption phenomena and concluded that the first step of vulcanization is adsorption of the sulphur, after which a part of it becomes chemically combined.

The evidence in favor of the chemical theory may be summarized as follows:

1. There is no process by which the combined sulphur can be removed and the original rubber regenerated. Reclaiming processes remove only the free sulphur.

A possible exception to this statement may be found in a late patent to Spence (U. S. 1,235,850) in which he claims to actually devulcanize rubber. After the removal of the free sulphur the combined sulphur is eliminated by heating in an aniline solution of metallic potassium or sodium for several hours at 175° C. The solution is filtered, the aniline distilled off and the rubber dissolved in benzol, when it is purified by treatment with water containing hydrochloric acid. Piperidine, caustic soda, and para aminodimethyl aniline, all powerful vulcanization accelerators, are recommended to assist and to speed up the devulcanization. Seventy-three per cent of the combined sulphur in ebonite was removed in one operation. The principle of the process is simple. Spence reasoned that all that was necessary was a powerful vulcanization accelerator in conjunction with an element capable of combining with and fixing the sulphur liberated from the rubber by the accelerator. The more powerful the accelerator the more rapid would be the devulcanization. It is to be sincerely hoped that Spence will be entirely successful in his experiments, and that their commercial application will not be long delayed. A reclaiming process which will truly devulcanize rubber is sorely needed. But should this process be successful it will not in the least invalidate the chemical theory, but will rather strengthen it, showing merely that another reaction takes place during which another substance combines with and removes the sulphur from the rubber. That such substances are powerful accelerators throws considerable light on the mechanism of acceleration, which will be discussed later.

2. Alexander showed that there was a definite stoichiometric relation between the maximum quantities of sulphur and bromine which may be added on. For instance, the maximum quantity of bromine which may be added is equivalent to 32 per cent of sulphur. Also, if 16 per cent of sulphur is already combined with the rubber the maximum amount of bromine which may be added is equivalent to 16 per cent of sulphur. Ebonite with 32 per cent combined sulphur cannot add on any bromine. You will note that we are here speaking of addition in the sense that it is known to the organic chemist and which differs considerably from substitution. The addition of bromine to rubber is considered by most chemists as taking place at the double bonds. It is not unreasonable then that sulphur should combine in the same way.

3. Vulcanization is subject to conditions like any other chemical reaction. Increased temperature accelerates it. The mass action effect of sulphur is marked and the catalytic behavior of certain substances is well known.

4. The work of Hinrichsen has shown that cold vulcanization by means of sulphur chloride is a true chemical reaction. The maximum quantity of sulphur chloride which may be added is about 33 per cent S_2Cl_2 which would indicate a compound $(C_{10}H_{16})_2S_2Cl_2$.

Vulcanization, according to the chemical theory, must be due to the chemical combination of sulphur with rubber, which combination probably takes place at the double bonds and is an addition and not a substitution. The existence of but one polyprene sulphide has been definitely established, namely, ebonite $(C_{10}H_{16})S_2$.

Adsorption Theory

This theory was advanced by Wolfgang Ostwald some years ago. He considered vulcanization to be simply a case of physico-chemical adsorption. The main points in support of his theory are:

1. Some free sulphur always remains after vulcanization. This fact Ostwald considers an evidence of adsorption on the ground that if vulcanization were a chemical reaction there should be certain conditions under which no free sulphur would remain. It is axiomatic that for any chemical reaction to go to completion the product of the reaction should be removed as fast as formed. This is obviously impossible in this case. The colloidal nature of rubber also tends to retard the reaction and prevents its completion.

2. Ostwald based another claim on the bends in Weber's curve. He pointed out that the different polyprene sulphides had never been isolated and that their existence might be explained equally well by the adsorption theory. In view of Spence's work the question requires no further comment.

3. Sulphur may be removed by suitable solvents on long treatment. This statement has been disproved many times. Spence has shown that the free sulphur

may be removed and that it is truly adsorbed. Combined sulphur is insoluble.

4. Figuring from Weber's data Ostwald obtained 1.87 for the temperature coefficient. Van't Hoff calculated that for a chemical reaction between rubber and sulphur a coefficient of 2 to 3.5 would be required. Adsorption gives a coefficient of 1.36 and while 1.87 is certainly nearer to 2 than 1.36, yet Ostwald held this to be in favor of his theory. The temperature coefficient based on Spence's work is 2.65.

5. Stern dissolved rubber and sulphur in fused naphthalene. His results were not satisfactory but he concluded that they were more in accord with the adsorption theory than with the chemical theory. It might be observed that rubber when dissolved in any solvent and heated, becomes rapidly depolymerized and if the operation is continued for any length of time it loses its normal properties and becomes more and more like the terpenes.

There is to date no evidence that a chemical reaction does not take place and the adsorption theory, as a theory to stand alone, has been definitely disproved.

Ostromyslenski's Theory

This theory came about through a study of the addition products of rubber with various aromatic compounds. Ostromyslenski found that substances which ordinarily form addition products such as picric acid, picryl chloride, triphenyl methane, etc., did not produce vulcanization but that compounds rich in oxygen such as nitro-compounds capable of giving up some of it did produce the "change." This led him to try benzoyl peroxide which readily yields oxygen, and it also vulcanized. He obtained best results with 1:3:5 trinitrobenzol and benzoyl peroxide, $C_6H_5—CO—O_2—CO—C_6H_5$. Physical tests on rubbers vulcanized according to his directions were made by Stevens' and are given in Tables I and II. The value of his work has been questioned on the ground that his "vulcanized" products were inferior to rubber vulcanized by sulphur. This is true, all but benzoyl peroxide and trinitrobenzol give hopelessly low results, and these while better than the rest, do not produce a vulcanized product equal to that of sulphur. However, he did obtain the "change" and his products were in most cases superior to the original crude rubber.

Because of the fact that substances with such widely different chemical and physical properties as the peroxides, nitro-compounds, sulphur and sulphur chloride, all produce vulcanization it is probable that vulcanized rubber as we know it is not the product of a simple chemical reaction, but that the vulcanizing substance first acts chemically on a small portion of the rubber forming a derivative which is in turn adsorbed by the unchanged rubber.

He further supported his theory by obtaining vulcanized products with rubber bromide and hydrochloride.

His theory is then, that only on polyprene sulphide, $C_{10}H_{16}S_2$ is formed, and that this substance being adsorbed on the remaining rubber gives it the properties which lead us to call it vulcanized. Thus he combined both the chemical and adsorption theories. No one has yet, to my knowledge, produced vulcanized rubber by heating caoutchouc with polyprene sulphide. This may

[1] *U. S. P.*, March 24, 1917. *J. S. Chem.*, I, 1916, p. 988.

Table I

Vulcanizing agent	1:3:5 Trinitrobenzol								Sulphur	Trinitro-Benzol and Sulphur
Parts same	4	4	1	1	1	4	1	4	10	1 10
Other ingredients				Litharge	*PbO*	*PbO*	*MgO*	*MgO*		
Parts same				30	30	30	30	30		
Cure, min. @ 140° C	5	10	60	90	5	60	60	75	40	90	90
Color vulc. rubber	Black	Black	Brown	Brown							
Breaking load (gm. sq. mm.)	954	876	376	318	226	104	410	359	1067	1590	1223
Final length	8.56	7.80	8.69	8.56	5.15	2.74	7.3	7.13	5.42	9.36	9.7
Tensile product	82	68	33	27	12	3	31	26	58	149	119
Acetone extract, %	2.12	2.20	148	105	2 16	2 22	2 11		1 58		
Nitrogen in same (calc. on rubber)	.24	.10	.04	.06							

Table II

Vulcanizing agent	Dinitrobenzol		Benzoyl Peroxide					
Parts same	4	4	33%	33%	1 33%	1 33%	6.69%	6.67%
Cure, min. @ 140° C	90	120						
Cure, min. @ 130° C			60	30	60	30	15	10
Color vulc. rubber	Black	Black						
Breaking load (gm./sq. mm.)	56	53	34	29	35	57	412	389
Final length (orig. 100)	5.36	5.60	228	181	219	339	1025	1006
Tensile product	3	3	8	5	8	19	42	39
Acetone ext., %	1.36		1.17	3.04	2 00	2.01	2.18	381
Nitrogen in same (calc. on rubber)	.06	.06						

not be an objection because of the difficulties of obtaining $C_{10}H_{16}S_2$ in a condition in which it may be readily adsorbed. Before the theory can be accepted some one must find a solvent for or a method by which polyprene sulphide may be separated from the unchanged rubber. Should this be done, and it may be accomplished, it would not be the first time that the product of a chemical reaction adsorbed on the unchanged substance in varying amounts, gave rise to a belief in a whole series of compounds where only two actually existed. A classic example of this statement is found in the confusion in the past regarding the oxy-celluloses.

Erdmann's Theory

The friends of both the chemical and Ostromyslenski theories consider that a true chemical reaction takes place between rubber and sulphur. The Erdmann theory is of importance because it seeks to explain the mechanism of this reaction. At 160° C., which is practically the upper limit of vulcanizing temperatures, molten sulphur contains a large portion of thiozone molecules, S-S-S. It is considered that thiozone acts on rubber in the same manner as ozone producing a thiozonide of caoutchouc.

The theory is of particular interest in that it gives us a partial explanation of the behavior of organic accelerators. Ostromyslenski has produced some evidence that these catalysts are substances which are capable of forming thiozonides with sulphur. If this is true it is quite probable that vulcanization proceeds in the following consecutive steps:

1. The union of the accelerator with sulphur forming a thiozonide. No accelerator has yet been found which does not contain nitrogen. The junction likely occurs between the nitrogen and sulphur atoms.

2. The addition of the thiozonide to the rubber molecule.

3. The splitting off of the accelerator, leaving the sulphur attached to the rubber. We cannot be sure that this splitting off always occurs. In fact, there is an indication in the peculiar snap and altered physical properties of stocks vulcanized by the aid of hexamethylenetetramine, which makes it seem probable that the thiozonide of this accelerator does not split off the catalyst after combining with the rubber.

The point has been raised by Eaton that accelerators are not true catalyzers because they do not remain unchanged throughout the reaction. It is quite true, so far as we know, that no accelerator remains absolutely unchanged during vulcanization. But there is yet no evidence which would tend to indicate that the accelerator is not split off from the rubber in the unchanged condition and that the decomposition is not brought about by side reactions. For example, the odor of phenyl mustard oil is always noticeable about a thiocarbanilide stock when it is freshly removed from the vulcanizing press. Thiocarbanilide when heated under several conditions sets free phenyl mustard oil. There is no evidence to show that the decomposition of thiocarbanilide producing phenyl mustard oil during vulcanization is not a secondary reaction. Phenyl mustard oil $C_6H_5.N = C = S$ has comparatively little accelerating value.

Relation Between Coefficient of Vulcanization and Physical Properties.

This subject is one which has aroused rather severe controversies across the water during the past couple of years. In fact it is as yet unsettled. The term coefficient of vulcanization was introduced by Weber and means simply the percentage of combined sulphur based on the rubber. It is admitted by all concerned that a correctly vulcanized rubber gives more general satisfaction than one which has not the correct degree of cure. The point at issue is, What is the correct cure and how may it be recognized? The coefficient of vulcanization is certainly indicative but its use is restricted because very few rubbers are polymerized to the same degree. It is also limited by the difficulties surrounding a correct determination of combined sulphur since the universal method is to extract the free sulphur and determine the combined sulphur by difference. There is no method for determining the combined sulphur directly. The free sulphur, as has been already pointed out, is adsorbed. Its complete extraction within reasonable time is impossible. Consequently purity of solvent, kind of solvent, dimensions of extractor, time of extraction, condition of the rubber, etc., must all be rigidly defined before chemists may use the coefficient as a basis. After its determination is reduced to a working basis it is still of questionable value unless sulphides are determined. We look on rubber as having the empirical formula $(C_{10}H_{16})_n$, n being a variable. When it is low, as is the case for rubbers of low natural polymerization or for those which have been overworked on the mills, more sulphur combines on vulcanization than is the case for rubbers of high natural polymerization, as for example, fine Para. In other words, the coefficient of vulcanization is higher in the first mentioned cases. I do not wish to leave the impression that good rubber may be overworked on the mills and by the simple expedient of adding on more sulphur attain the properties of a correctly milled stock. Overmilling is always detrimental.

De Vries[2] has put the proposition well:

"From my experiments it is clear that the reaction between sulphur and rubber and the changes in the rubber-sulphur mixture which determine the mechanical properties as expressed in the stress-strain curve are two different processes which proceed independently of one another and that speaking in general it is not feasible to make deductions from one regarding the other."

The compounder has only a passive interest in the coefficient of vulcanization. He is entirely wrapped up in the physical properties of his stocks. The coefficient may be 2 or 6 provided his compound meets specifications. He realizes, of course, that he must always obtain the correct cure but he prefers to judge this point from the physical properties rather than by the coefficient of vulcanization. He bases his judgment on such considerations as tensile strength, stretch, set, the characteristics of the stress-strain curve, and on an indefinite something which he calls "feel" but which is really the summarization of his experience with the particular type of stock in question.

Production and Rate of Cure.

Vulcanization is essentially a chemical reaction. This statement is one in which every rubber chemist will concur. The rate of cure is susceptible to the same influences as effect the speed of a chemical reaction. The most important considerations are:

1. Mass action.
2. Catalysis.
3. Temperature.

MASS ACTION

As would be expected, an increase in sulphur content decreases time required for vulcanization. The mass action effect has been investigated by Skellon.[3] He reports the following figures:

	Added Sulphur						
Time of Cure	3%	5%	10%	20%	30%	40%	50%
	Combined Sulphur						
30 min. @ 140° C.	.36	.44	.63	.59	.55	.51	.48
1 hr. @ 140° C	.46	.63	1.07	1.05	.95	.83	.76
1 hr. 30 min. @ 140° C	.70	1.02	1.65	1.64	1.47	1.32	1.15
3 hrs. @ 140° C	1.42	2.06	3.35	4.07	3.58	3.13	2.81
6 hrs. @ 140° C	.	2.88	6.18	11.33	11.62	10.93	10.22
9 hrs. @ 140° C	.	.	8.76	17.32	24.10	25.5	25.0

CATALYSIS

Whether we choose to call it catalysis or acceleration, its effects are to be seen in the behavior of every mix on vulcanizing. Some substances speed up the reaction while others retard it. The chief retarders or negative accelerators are:

1. Alkali in excess of 3 per cent.
2. Acids.
3. Molybdenum sesquioxide over 10 per cent.
4. Nickel oxide.
5. Phenylhydrazine.
6. Glucose.
7. Methylene blue.
8. Most oils and greases.
9. Asphaltic products.

Some of these are not true negative catalyzers but mere sulphur removers in that they react with sulphur as easily or easier than rubber.

In a previous paper[4] the writer gave a partial review of the organic accelerators. To this list may now be added:

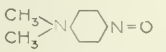
[2] *I. R. J.*, Jan. 20, 1917, p. 17.

[3] Rubber Industry, 1914.

[4] This journal, Sept. 1, 1916, p. 231.

1. Para Nitroso-Dimethyl Aniline.

Nitroso derivatives of methyl aniline, dimethyl aniline, ethyl aniline and diphenylamine are powerful accelerators.[3] P-Nitroso-dimethyl aniline, sold under the trade name of accellerene, is the best. It is a green crystalline powder melting at 85 deg. Cent. and is produced by the action of nitrous acid on dimethyl aniline. The structural formula is



Peachy states that the addition of .3 to .5 parts accellerene to a mix of 100 parts rubber, 10 parts sulphur, cuts the time from 1 hour at 140 deg. Cent. to 20 to 25 min. at the same temperature. This mix probably contained, though not stated, some mineral accelerator such as lime or magnesia. With hard rubber the addition of 0.75 per cent accelerene to a mix of 100 parts rubber, 40 parts sulphur cuts the time from 6 hr. at 140 deg. Cent. to 2 hr. In general the addition of .3 to .5 parts of P-Nitroso-dimethyl aniline to high quality stocks cuts the time to 1/3 or 1/4 that formerly required. It cannot be used with antimony sulphide, litharge, or shoddy. The addition of magnesia is a decided help.

2. Condensations between aldehydes and amines.

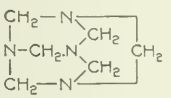
Type reaction: Benzaldehyde with aniline forming benzylidene aniline.

$$C_6H_5CHO + H_2NC_6H_5 = H_2O + C_6H_5.CH:N\,C_6H$$

This is an active accelerator but less so than P-Nitroso-dimethyl aniline.

3. Hexamethylene tetramine:

This substance $(CH_2)_6N_4$ is produced by the action of ammonia on formaldehyde at ordinary temperatures. It is a crystalline basic substance having the structural formula:



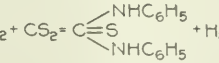
This accelerator must not be used in conjunction with litharge, magnesia, or lime. About the only metallic oxide with which it is not incompatible is zinc oxide. It is about twice as powerful as thiocarbanilide, and must be used in rather small amounts. It gives a stock a peculiar snap and stiffness unlike any other accelerator known.

4. Piperidine-piperidyl-dithio-carbaminate:

This accelerator is by far the most powerful of all those known to-day. First mention of it was made by Ostromyslenski[4]. It is formed by the action of carbon bisulphide on piperidine.

$$2(CH_2)_5NH + CS_2 = [(CH_2)_5NH]_2CS_2$$

The reaction is similar to that producing thiocarbanilide from aniline and carbon bisulphide except that no hydrogen sulphide is evolved.



Thiocarbanilide

The addition of .5 to 1 per cent in conjunction with 5 per cent magnesia or litharge diminishes the time required for vulcanization to 1/40th of the original time. In the presence of 2 to 5 per cent of the accelerator, vulcanization of either synthetic or natural rubber is complete in a few seconds at 130 deg. Cent. Stocks containing it to the extent of 2 per cent will become fully vulcanized on standing at room temperature for a month. Unfortunately it is far too powerful and too expensive for factory practice.

Accelerators in more ways than one are similar to explosives. Properly used they are a boon, but used without discretion they can produce more havoc on a firm's balance sheet than anything I know of. To get results one must have long experience with them and must take nothing for granted. In general, a combination with one or more of the metallic oxides works well, but this must be very carefully studied before final decision.

TEMPERATURE

As stated previously, vulcanization is essentially a chemical reaction brought about by heat. In common with such reactions the application of a higher temperature brings it to completion in a shorter time. It was formerly held that high temperatures were harmful, and so they are when the nature of the article is such that heat flow is very slow, but whenever the piece can be brought to press temperature through and through in a very short time, a higher temperature for a shorter time produces a better article than a lower one for a longer time. The subject has been investigated by Kratz[7], who reports the following figures on a stock made up of 100 parts first latex crepe, 100 parts zinc oxide, and 5 parts sulfur.

Time, Min.	Steam Pressure, Lb. Sq. In.	Temperature, °F.	Tensile Strength, Lb./Sq. In.	Stretch, per Cent	Tensile Product
120	36	282	2896	750	217
90	43	290	2747	725	200
60	50	298	2755	725	200
43	55	303	3064	725	222
30	60	307	2947	775	229
22	65	312	2854	800	228
18	70	316	2563	750	193
14	75	320	2656	725	192
11	80	324	2545	750	191
8	85	328	2970	800	238

The relation between temperature and rate of vulcanization has been investigated by Bourn[8], who has summarized his experiments in the following statements:

1. The velocity of the combination increases faster than the increase of temperature, and decreases correspondingly with a decrease of temperature.

2. For every increase in temperature of about 11 deg. Fahr. the velocity is doubled, and for each decrease in temperature of about 11 deg. Fahr. the time required is doubled.

3. Above 304 deg. Fahr., when the constitution of sulfur changes, the velocity doubles in approximately 25 deg. Fahr. instead of 11 deg. Fahr.

PRODUCTION.

The novice might imagine that if one can use accelerators and reduce the time required for vulcanization from 1 hr. to 25 min. that the desirable thing to do would be to put in more accelerators and pull the time down to 5 min. or to zero time for that matter. That line of reasoning would be correct provided no condi-

[3]British Pat. 4263, 1914. Peachy, I. R. J., May 12 and 19, 1917
[4]J. Russ. Phys. Chem. Soc., 47, 1441-53, 1915. Chem. Abst., 1916, p. 3176.

[7]I. R. J., 1916, p. 661
[8]Rubber Industry, 1914.

tions other than production had to be met. Unfortunately there are other factors to consider. Chief of these are:

1. Stages in factory process.
2. Heat conductivity.
3. Stocks in contact.

STAGES IN FACTORY PROCESS

These include milling, calendering, tubing, etc., regular factory operations during which there must be no scorching. By scorching I mean the partial vulcanization brought about by overheating. This tends to give lumpy stocks unsuitable for further operations. A stock must not be too heat-sensitive.

HEAT CONDUCTIVITY

Rubber is not a good conductor of heat. Small articles, such as the average piece of molded goods, heat up quickly, but large bulky articles require an appreciable time for the heat to penetrate into the interior. Built-up articles such as hose, belting, etc., containing cotton duck do not permit a rapid flow of heat to the interior and must be cured at comparatively low steam pressure, 30 lb. or under; the idea being to prevent the outside layers from becoming over-vulcanized while the interior would be yet under-cured.

A low temperature requires a long period of heating and reduces production. The usual manner of circumventing this difficulty is to use a "rising cure." A typical example of such a cure is as follows:

20	min.	@	20	lb.	steam	pressure
30	"	@	30	"	"	"
40	"	@	40	"	"	"

As the name implies, the heat is increased in successive steps which are made far enough apart to allow complete penetration and equalization before going on with the next step.

STOCKS IN CONTACT

Under this head we must consider not only such stocks as may be in actual contact but all the stocks which enter into the makeup of the article. For example, in the pneumatic tire we have different stocks for the tread, cover, cushion, breaker strip, sidewall and bead. The compounder must so adjust his stocks that all of them will reach the desired degree of vulcanization at the end of the period. Most beads are semi-hard rubbers and must be partly cured before being built into the tire. In general, stocks in contact should have the same rate of cure.

A New Source of Potash

Present Development and Future Possibilities of Extraction from Chile Nitrate

A SOURCE of potash which has not been seriously considered heretofore, and which has enormous possibilities, was described by C. M. Barton, vice-president of the du Pont Nitrate Company, at a recent meeting of the Delaware Section of the American Chemical Society in Wilmington. He stated that not only had the du Pont Company succeeded in producing potash in paying commercial quantities from the Chilean nitrate ores, but that it had given its processes to the representatives of companies from allied and neutral countries which operate plants in the nitrate fields of Chile.

The du Pont Company produces only about one per cent of the output of the Chilean nitrate fields, but it has succeeded, by its processes, in producing 10,000 tons a year of a product containing 25 per cent of potassium nitrate. This is equivalent to about 1200 tons of potassium oxide.

The others of the 200 nitrate plants in Chile are capable of producing an average quantity of potash equal to that produced by the du Pont Company. On this basis the production would be 240,000 tons a year, but the process can be further developed and improved. There is good reason to believe that in a short time it can be improved to such an extent that instead of recovering about one-third of the potash in the ore it may be possible to recover virtually all and thereby bring the total possible output up to 720,000 tons a year. This is almost as much as the entire pre-war consumption of potash in the United States.

Germany's sale of potash before the war to the entire world amounted only to about 900,000 tons a year.

Mr. Barton outlined the process during his talk and stated that this process had been in operation and had been improving constantly for a long while. He said:

> "From the beginning of our operations we had known that our caliche at Oficina "Delaware" contained some potash and that our product contained on an average about 5 per cent of nitrate of potash. Working constantly on various theories for securing better yields and knowing that we could secure a desirable product for our refineries if we could get a nitrate containing a higher percentage of nitrate of potash, we found that by taking the mother liquor coming back from the crystallizing pans and evaporating it to a high density there was deposited from this upon cooling a product which contained on an average about 25 per cent of nitrate of potash. We had not found it a practical proposition to install evaporators for this purpose until in the latter part of the year 1914, when the price of muriate of potash started to climb up from $35 per ton to a peak price of about $500 per ton. In October, 1914, we produced our first H. P.—or high potash nitrate—and by securing further evaporators were able to increase our production of this, so that we have for a year or more secured about 25 per cent of our output in this form. We estimate roughly that up to October, 1917, we secured from this source at least 5000 tons of nitrate of potash, in the form of about 20,000 tons of our so-called 25 per cent H. P. nitrate.
>
> "We erected three evaporators near the end of the maquina. The first was an old evaporator which had formed a part of the old Nordenflycht maquina, which was on the property when we bought it. The old maquina was torn down and parts of this old evaporator had been utilized for other purposes, but were reassembled, and it has been giving steady use. The other two evaporators we bought from another nitrate company that had received but never erected them, owing, we believe, to their having gotten 'cold feet' due to the trouble others had experienced through corrosion in evaporators when treating the liquors of the usual operations. We anticipated the corrosive effects, suffered from them, but a year ago were able to eliminate or at least minimize the corrosion very effectively by the addition to the liquor of a small amount of sodium carbonate.
>
> "You can understand that this H. P. nitrate has proven very valuable to the du Pont Company, and we kept rather quiet about this portion of our operations until shortly after our entry into the war. It was then realized that the needs of the country were such that it was to the interest of the du Pont Company to surrender its position of vantage, and the representatives of the allied and neutral governments, whose subjects operate nitrate plants in Chile, were advised that the du Pont Company was willing to share with them its secrets in the production of this material."

The value of this process is emphasized by the fact that potash produced in Chile is a by-product of the nitrate industry, and hence can be produced very cheaply.

The Effect of Addition Agents in Flotation—III.

By M. H. THORNBERRY and H. T. MANN

As in the preceding discussion of the effect of addition agents in flotation, the results obtained by the addition of various chlorides are shown graphically in Charts 10, 11 and 12. The numerals on the charts are the numbers of the various experiments, three being made without any additions and four with each of the different agents. Those without addition agents are numbered 1, 2, 3 and 0, the last showing the average results of the first three. The numbers of experiments with addition agents are given in the following paragraphs, four to each experiment, and indicate results obtained respectively with 5, 15, 25 and 50 cc. of each agent.

To save repetition in the discussion of the results we shall refer in this article to Cleveland Cliffs Iron Company's flotation oil No. 1, as "oil No. 1," and to General Naval Stores flotation oil No. 17, as "oil No. 17."

The reader should also bear in mind that when statements are made that a certain reagent raised or lowered the grade of concentrate or extraction, those results are compared with the results obtained when oil was used without any reagent.

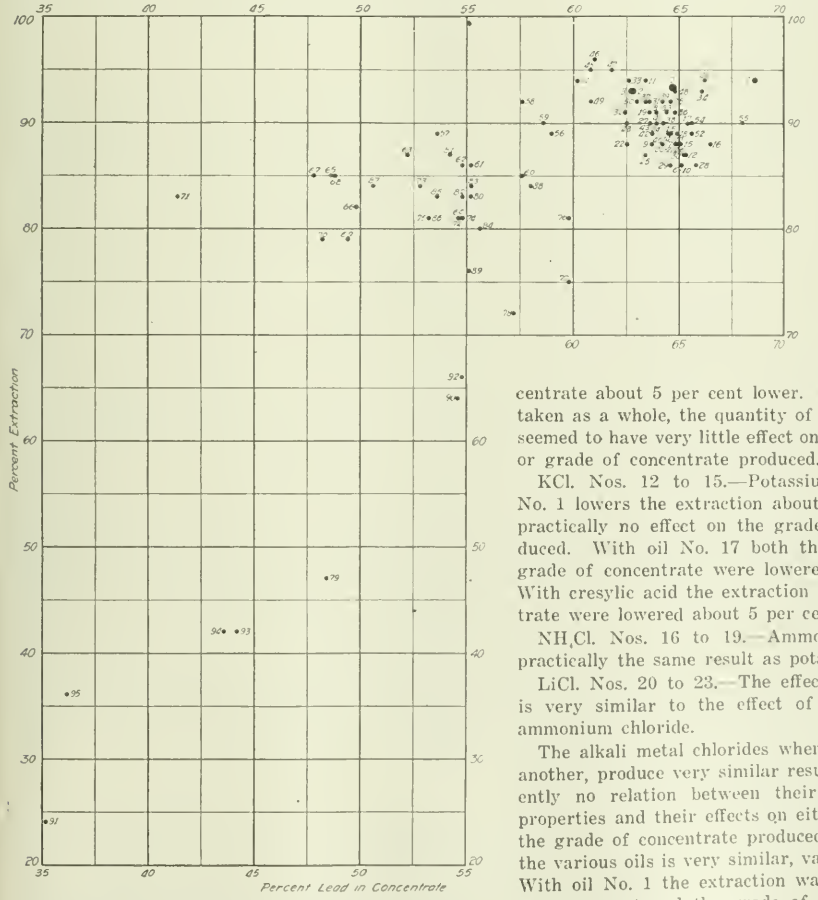


CHART 10. ADDITION AGENTS IN FLOTATION. EFFECT OF CHLORIDES ON THE FLOTATION OF GALENA WITH CLEVELAND CLIFFS IRON CO.'S OIL NO. 1

CHLORIDES

Alkali Metal Chlorides

NaCl. Nos. 8 to 11.—Sodium chloride when used with oil No. 1 had very little effect. The average extraction was about 4 per cent lower, while the grade of concentrate was practically of the same grade as when no reagent was present. With oil No. 17 the extraction was lowered 9 per cent to 10 per cent, and the lead tenor of the concentrate was about 9 per cent lower. With cresylic acid the extraction was about 6 per cent lower and the concentrate about 5 per cent lower. When the results are taken as a whole, the quantity of sodium chloride used seemed to have very little effect on either the extraction or grade of concentrate produced.

KCl. Nos. 12 to 15.—Potassium chloride with oil No. 1 lowers the extraction about 5 per cent, but had practically no effect on the grade of concentrate produced. With oil No. 17 both the extraction and the grade of concentrate were lowered about 10 per cent. With cresylic acid the extraction and grade of concentrate were lowered about 5 per cent.

NH_4Cl. Nos. 16 to 19.—Ammonium chloride gives practically the same result as potassium chloride.

LiCl. Nos. 20 to 23.—The effect of lithium chloride is very similar to the effect of both potassium and ammonium chloride.

The alkali metal chlorides when compared, one with another, produce very similar results. There is apparently no relation between their individual chemical properties and their effects on either the extraction or the grade of concentrate produced. Their action with the various oils is very similar, varying only in degree. With oil No. 1 the extraction was lowered 4 per cent to 5 per cent and the grade of concentrate produced averages less than 1 per cent low. With oil No. 17 the extraction was lowered about 12 per cent and the grade

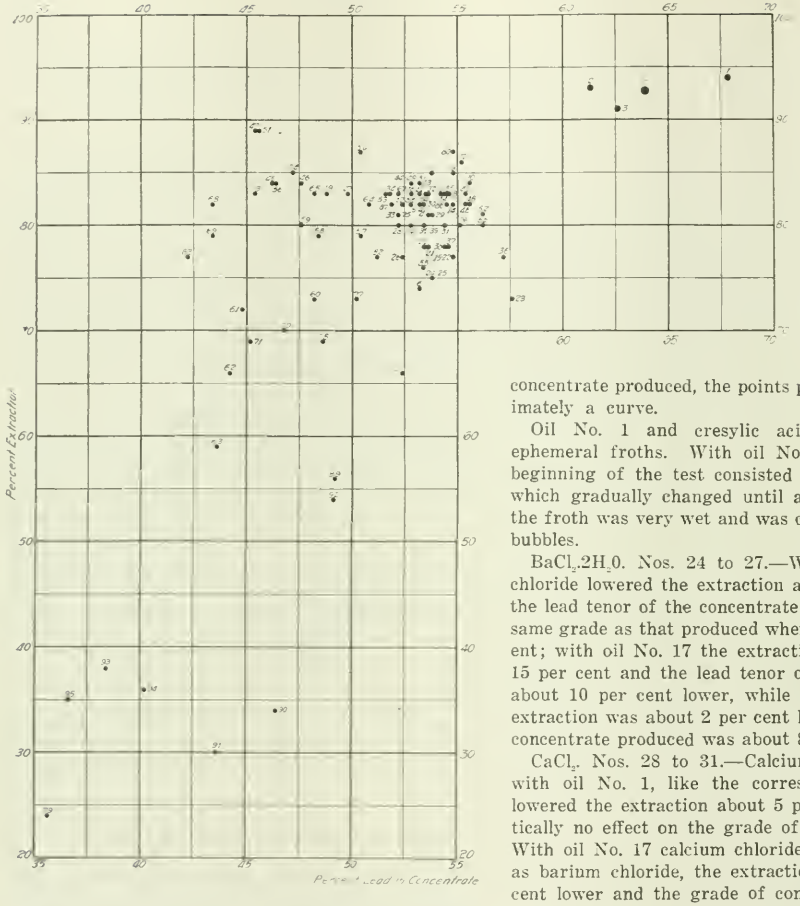


CHART 11. ADDITION AGENTS IN FLOTATION. EFFECT OF CHLORIDES ON THE FLOTATION OF GALENA WITH GENERAL NAVAL STORES FLOTATION OIL NO. 17

of concentrate was about 10 per cent low, while with cresylic acid both the extraction and the grade of concentrate were lowered about 5 per cent. The characteristic froth produced by these chlorides consists of large bubbles which break up quickly.

Alkaline Earth Chlorides

HCl. Nos. 4 to 7.—Hydrochloric acid when used with oil No. 1 lowered the extraction about 5 per cent, while it had practically no effect on the lead tenor of the concentrate. The quantity of hydrochloric acid apparently made little difference, either on the extraction or the grade of concentrate produced. With oil No. 17 the extraction was lowered about 10 per cent when 5 cc. of the reagent was used and 26 per cent when 50 cc. was used, the results falling roughly in a straight line. The grade of concentrate was lowered about 10 per cent in each test regardless of the amount of the reagent present. With cresylic acid and 5 cc. of hydrochloric acid the extraction was practically the same as when no addition agent was present, but when 50 cc. was added the extraction was lowered about 13 per cent. The lead tenor of the concentrate varied from 4 per cent lower with 5 cc. to 7 per cent lower with 50 cc. With this oil, the greater the quantity of hydrochloric acid used the poorer the extraction and the lower the grade of concentrate produced, the points plotted making approximately a curve.

Oil No. 1 and cresylic acid produced ordinary ephemeral froths. With oil No. 17 the froth at the beginning of the test consisted of large, dry bubbles, which gradually changed until at the last of the test the froth was very wet and was composed of very small bubbles.

$BaCl_2.2H_2O$. Nos. 24 to 27.—With oil No. 1 barium chloride lowered the extraction about 5 per cent, while the lead tenor of the concentrate was practically of the same grade as that produced when no reagent was present; with oil No. 17 the extraction was lowered about 15 per cent and the lead tenor of the concentrate was about 10 per cent lower, while with cresylic acid the extraction was about 2 per cent lower and the grade of concentrate produced was about 8 per cent lower.

$CaCl_2$. Nos. 28 to 31.—Calcium chloride when used with oil No. 1, like the corresponding barium salt, lowered the extraction about 5 per cent, but had practically no effect on the grade of concentrate produced. With oil No. 17 calcium chloride is not so detrimental as barium chloride, the extraction being about 12 per cent lower and the grade of concentrate about 10 per cent lower. With cresylic acid the extraction is about 3 per cent higher than the extraction obtained when no reagent was present, while the grade of concentrate is about 6 per cent lower.

$SrCl_2$. Nos. 32 to 35.—Strontium chloride with oil No. 1 has practically no effect. With oil No. 17 the effect was practically the same as that produced by calcium chloride. With cresylic acid the extraction was lowered about 6 per cent and the grade of concentrate was 7 per cent to 8 per cent lower.

$MgCl_2.6H_2O$. Nos. 36 to 39.—Magnesium chloride has practically the same effect as strontium chloride.

The results obtained with the alkaline earth chlorides and hydrochloric acid were very similar in every respect to those obtained with the alkali metal chlorides.

Metallic Chlorides

$MnCl_2$. Nos. 40 to 43.—The quantity of manganese chloride seems to have practically no effect on the results obtained. With oil No. 1 the extraction was lowered about 4 per cent with practically no effect on the grade of concentrate produced; with oil No. 17 the extraction and the grade of concentrate were about 10 per cent lower, while with cresylic acid the extraction

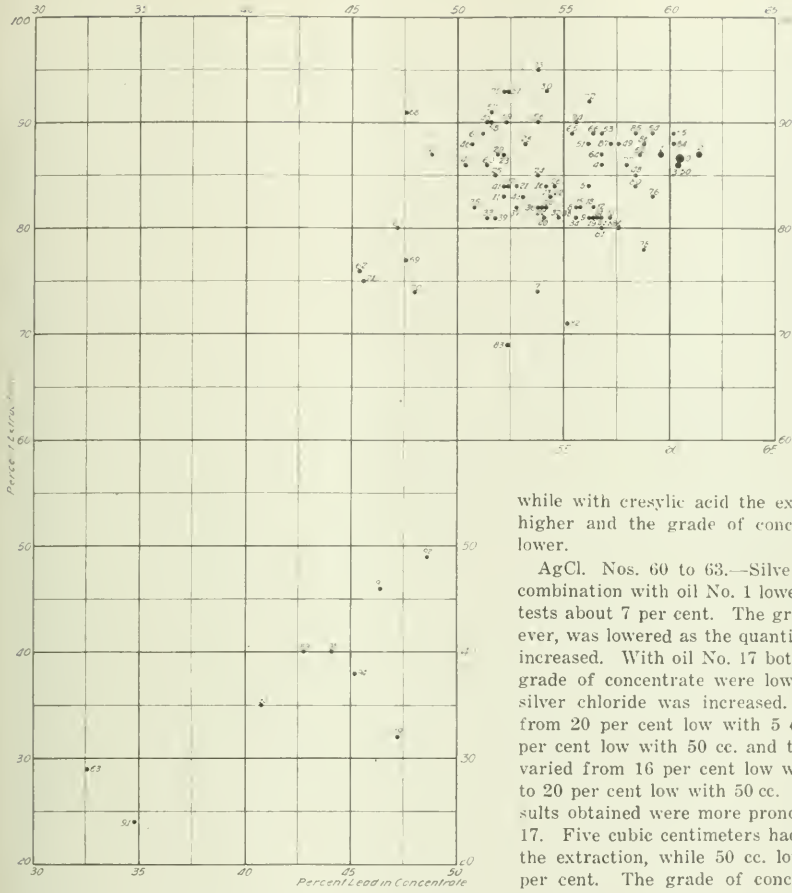


CHART 12. ADDITION AGENTS IN FLOTATION. EFFECT OF CHLORIDES ON THE FLOTATION OF GALENA WITH CRESYLIC ACID

was 5 per cent lower and the grade of concentrate was 6 per cent to 7 per cent lower.

$NiCl_2$. Nos. 44 to 47.—Nickel chloride produced results which were more erratic than any of the previous chlorides. Considering the results as a whole, the extraction is better and the grade of concentrate is lower than with either the alkali metal chloride or the alkaline earth chloride.

$CoCl_2.6H_2O$. Nos. 48 to 51.—The general action of cobaltous chloride is very similar to that of nickel chloride. The results obtained were more erratic with oil No. 1 and cresylic acid than with oil No. 17. With oil No. 17 an increased quantity of cobaltous chloride increased the extraction and lowered the grade of concentrate.

$FeCl_3.6H_2O$. Nos. 52 to 55.—With oil No. 1 ferric chloride lowered the extraction about 4 per cent and slightly raised the grade of concentrate produced; with oil No. 17 both the extraction and the grade of concentrate were lowered 10 per cent, while with cresylic acid the extraction was about 2½ per cent higher and the grade of concentrate produced was about 12 per cent lower.

$CuCl_2.2H_2O$. Nos. 56 to 59.—The effect of cupric chloride, when compared with the effect of previous chlorides, was to produce a low-grade concentrate with little effect on the extraction. With oil No. 1 the extraction was 4 per cent lower and the grade of concentrate was 7 per cent lower; with oil No. 17 the extraction was 12 per cent lower and the grade of concentrate was 16 per cent lower, while with cresylic acid the extraction was 4 per cent higher and the grade of concentrate was 8 per cent lower.

AgCl. Nos. 60 to 63.—Silver chloride when used in combination with oil No. 1 lowered the extraction in all tests about 7 per cent. The grade of concentrate, however, was lowered as the quantity of silver chloride was increased. With oil No. 17 both the extraction and the grade of concentrate were lowered as the quantity of silver chloride was increased. The extraction varied from 20 per cent low with 5 cc. of the reagent to 35 per cent low with 50 cc. and the grade of concentrate varied from 16 per cent low with 5 cc. of the reagent to 20 per cent low with 50 cc. With cresylic acid the results obtained were more pronounced than with oil No. 17. Five cubic centimeters had practically no effect on the extraction, while 50 cc. lowered the extraction 57 per cent. The grade of concentrate produced varied from 9 per cent lower with 5 cc. to 28 per cent lower with 50 cc.

$PbCl_2$. Nos. 64 to 67.—With oils No. 1 and No. 17 lead chloride lowered the extraction 10 per cent and the grade of concentrate 12 per cent. With cresylic acid the extraction was 1 per cent higher, while the grade of concentrate produced was 5 per cent lower.

$HgCl_2$. Nos. 68 to 71.—Mercuric chloride with oil No. 1 lowered the extraction apparently 12 per cent and lowered the grade of concentrate about 18 per cent. With oils No. 17 and cresylic acid the quantity used seemed to have little effect on the grade of concentrate produced, which in the case of oil No. 17 was 19 per cent lower and with cresylic acid 13 per cent lower. The extraction depends on the quantity of the salt used, varying with oil No. 17 between 10 per cent to 23 per cent lower and with cresylic acid between 4 per cent higher and 11 per cent lower.

$AlCl_3.6H_2O$. Nos. 72 to 75.—The quantity of aluminium chloride used seemed to have little effect on either the grade of concentrate produced or on the extraction. With oil No. 1 this reagent lowered the extraction 13 per cent and the grade of concentrate 11 per cent; with oil No. 17 the extraction and grade of concentrate were lowered respectively 10 per cent and 14 per cent, while

with cresylic acid the extraction was raised 6 per cent and the grade of concentrate was lowered 6 per cent.

$SnCl_2.2H_2O$. Nos. 76 to 79.—Stannous chloride had a very detrimental effect on both the extraction and the grade of concentrate produced. Its detrimental action depends on the quantity used, decreasing both the extraction and the grade of concentrate produced, as the quantity of the reagent was increased. With oil No. 1 the extraction varied from 5 per cent lower with 5 cc. of the solution to 46 per cent lower with 50 cc. of the solution, while the grade of concentrate varied respectively from 5 per cent lower to 17 per cent lower. With oil No. 17 the extraction varied from 13 per cent low with 5 cc. of the solution to 69 per cent low with 50 cc. and the grade of concentrate likewise varied from 9 per cent to 28 per cent lower. With cresylic acid small quantities of this reagent had very little effect on either the extraction or the grade of concentrate produced, but when 50 cc. of the solution was added the extraction was lowered 55 per cent and the grade of concentrate was lowered about 10 per cent.

$ZnCl_2$. Nos. 80 to 83.—The results obtained when zinc chloride was used varied greatly with the different oils. With oil No. 1 the extraction and grade of concentrate were lowered 8 per cent and 11 per cent respectively, there being little difference in the results obtained with the various quantities of the reagent. With oil No. 17 the extraction varied between 5 per cent and 15 per cent lower and the grade of concentrate varied between 9 per cent and 22 per cent lower, depending on the quantity of the reagent used. With cresylic acid the extractions varied between 3 per cent and 8 per cent lower and the grade of concentrate between 2 per cent and 8 per cent lower, depending on the quantity of the salt used, the points as plotted making a fairly good curve.

BiOCl. Nos. 84 to 87.—The quantity of bismuth oxychloride used had very little effect on either the extraction or the grade of concentrate produced. With oils No. 1 and No. 17 the extraction and grade of concentrate were respectively 10 per cent and 12 per cent lower. With cresylic acid the extraction was about 2 per cent higher, while the grade of concentrate produced was 2 per cent lower.

UCl_4. Nos. 88 to 91.—Uranium chloride had a very marked effect on the results obtained. With oil No. 1 5 cc. of this salt lowered the extraction and grade of concentrate produced 9 per cent and 6 per cent respectively, while 50 cc. lowered the extraction and grade of concentrate 70 per cent and 29 per cent respectively. With oil No. 17 the extraction varied between 16 per cent low with 5 cc. of the solution to 62 per cent low with 50 cc., and the grade of concentrate likewise varied between 11 per cent and 20 per cent lower. With cresylic acid the extraction varied between 6 per cent low with 5 cc. of the solution to 63 per cent low with 50 cc., and the grade of concentrate likewise varied between 3 per cent and 25 per cent low.

$CdCl_2.2H_2O$. Nos. 92 to 95.—Cadmium chloride as in the case of all previous salts containing cadmium had a very detrimental effect on both the extraction and grade of concentrate produced. With oil No. 1 the extraction varied between 28 per cent and 58 per cent lower and the grade of concentrate betwen 10 per cent and 28 per cent lower. With oil No. 17 the extraction varied between 39 per cent and 58 per cent lower and the grade of concentrate between 15 per cent and 28 per cent lower. With cresylic acid the extraction varied between 36 per cent and 49 per cent lower and the grade of concentrate between 12 per cent and 16 per cent lower. The experimental work with cadmium salts up to the present time indicate that very small quantities of cadmium have a very marked detrimental influence on both the extraction and the grade of concentrate produced by flotation. Results also indicate that additions of larger quantities of the salt have no more effect than the smaller quantities.

There was nothing special in the action of the chlorides other than the general effect on the extraction and grade of concentrate. The froths are very uniform, generally consisting of small or medium sized bubbles, which break up very quickly.

Experiment Station and Dept. of Met.,
Missouri School of Mines and Metallurgy,
Rolla, Mo.

Increased Output of Crystalline Graphite.—The production of crystalline graphite in the United States was increased last year about 24 per cent, amounting to approximately 6800 tons, against 5466 tons in 1916. About 60 per cent of the output in 1917 was flake graphite suitable for making crucibles; the remainder was dust graphite. These figures are a preliminary estimate of the Geological Survey.

The production from the Alabama field, instead of being more than double that of 1916, as would have been expected from the large number of new companies entering the field, shows only a slight increase, for owing to freight embargoes the Alabama producers have been unable to market their product. The other producing fields have made notable increases in production but not sufficient to increase greatly the total output.

The imports of crystalline graphite in 1917 as shown by the records of the Bureau of Foreign and Domestic Commerce for the first ten months and as estimated for November and December, amounted to more than 32,000 tons, of which 25,000 tons came from Ceylon. If the Alabama producers could have had free access to the markets a much larger proportion of our needs could have been supplied from domestic sources.

The value of the graphite produced in 1917 is considerably greater than that produced in 1916, for No. 1 flake has commanded a higher price and many of the mills marketed a larger proportion of this grade in 1917 than formerly.

Figures showing the production of amorphous graphite are not yet available.

Chimie & Industrie.—The first issue of *Chimie & Industrie*, the official journal of the recently formed Société de Chimie Industrielle of France, has appeared. It contains a statement on the aims of the society, its program and organization and the fields to be covered by the journal, which will appear monthly. The editor-in-chief is Prof. Camille Matignon of the Collège de France. Judging by the appearance of the first number and the advertisements contained therein, the journal should prove successful. It has indeed made a very good start. The best wishes of this journal go to our brothers in France and we look forward to seeing it play an important part in the industrial development of that country. The recently formed New York Section of the Society now has about 165 members.

Ceramics and the War*

By Edward W. Washburn†

At the time this building was dedicated last year one of the professors at a neighboring university happened to see one of the dedication pamphlets bearing a picture of the new Ceramics Building upon it, and he was curious as to why such a large building should be constructed for such a subject as ceramics. It appears that he was under the impression that the term "ceramics" was applied to the art of deciphering the ancient cuneiform inscriptions which the Assyrian and Babylonian peoples made on clay tablets. This incident illustrates in a way the condition which exists in the mind of the average man regarding the subject of ceramics. Either he has never heard the term, and consequently it conveys no meaning whatever to him, or else he perhaps associates it only with the beautiful vases and the ancient pottery which he sees in the museums. Certainly the average man would be astonished if he were told that the science and art of ceramics was of the utmost importance in the prosecution of a war. It is nevertheless a fact that modern warfare could not be conducted without the assistance of the ceramic engineer and artisan, and I wish to point out briefly at this time some of the fields in which ceramics is indispensable to a nation engaged in war.

I will begin my subject by telling you a story of the way in which the importance of one branch of this subject was first brought home to the English people early in the war. Not long after the war started, a committee from the British steel manufacturers waited upon the British government and stated that as far as they could determine their factories would be able to continue operation for only a few weeks longer, after which they would be obliged practically to shut down. Of course, that was a very serious state of affairs for a country just entering upon a big war, and the government and people would naturally be alarmed at such a prospect, and curious as to the causes which produced it. Now, if one were to ask the average citizen to hazard a guess as to a probable cause for the closing down of the steel works of a country he would probably think of labor troubles or transportation difficulties, or perhaps lack of ores or fuel, or other raw material; but I venture to say that the true source of the difficulty which confronted the English manufacturers would never be suspected. As a matter of fact, the crisis in which the British manufacturers found themselves was caused by the fact that the supply of chemical glassware in England was approaching exhaustion, and since all of this glassware had been imported from Germany, there appeared to be no way of renewing the supply. Now, a modern chemical laboratory cannot be operated without a variety of different kinds of vessels and apparatus constructed from a special kind of glass, and when the laboratory of a steel works ceases to function the plant can no longer operate, since it is operated entirely under the control of its laboratory. The chemists of Great Britain were appealed to in the crisis, and they immediately set to work to find out how to make chemical glass, and fortunately they were able to solve the problem before the crisis became acute; but for a while the government was very much alarmed, and at one time an inventory of all the chemical glassware in the kingdom was contemplated so that it could be confiscated, if necessary, for the national needs. Before such a necessity arose the chemists had found out how to make a sufficiently good grade of chemical glassware to meet the immediate needs.

Curiously enough, about the same time the coal miners were confronted with a similar situation, and here again the source of the trouble was glass. The kind of glass used in miner's lamps had been obtained entirely from Germany, and since the safety of hundreds of miners was dependent upon the heat-resisting power of the glass in their lamps, it was evident that this problem also required an immediate solution. Both of these problems are in the realm of ceramic chemistry, and both of them were solved by the British chemists before the situation became a dangerous one.

The immediate appearance of these two, so to speak, ceramic crises in England called attention to a situation which had existed in England for a long period of time. During the decade immediately preceding the outbreak of the war, British chemists and physicists had repeatedly directed the attention of the public to the importance of scientific education and scientific research, and had warned the country of the dangers which threatened both its industrial and its political life because of the failure of the government to appreciate the backwardness of the nation in this respect, and because of the resultant dependance of the country upon Germany for many essential materials. It is well known that the backbone of Germany's war strength has been her chemists, and a large element in the weakness of Great Britain early in the war arose from her state of scientific unpreparedness in many chemical lines and the failuse of the government to make sufficient use—even after the outbreak of the war—of the chemical resources which the nation already possessed, and the utter ignorance on the part of the British officials of some of the simplest chemical facts of first importance in the conduct of the war. One illustration of this ignorance occurred during the early days of the war, when the British government prepared its first list of contraband of war. This was before the days of the food blockade, when foodstuffs were still allowed to be sent into Germany. All manufactured munitions and all materials which were used in the manufacture of munitions were declared contraband of war. Nevertheless, under the guise of food, large quantities of lard and other fats were imported by Germany without any attempt on the part of Great Britain to prevent it. Finally the attention of the government was called to the fact that it was permitting Germany to import all the lard which she wanted, and that the Germans were making munitions of war out of the lard. Now, lard is one of the principal sources of glycerine, and when glycerine is treated with a mixture of sulphuric and nitric acids a rather important article known as nitroglycerine is the result. But apparently no one connected with the British government was aware of this fact, and when attention had been called to it by the chemists of the country one of the public officials of Great Britain is said to have stated in defense of the government that the manufacture of nitroglycerine from lard was *a recent German discovery*, and that consequently the British government could not be expected to know of it.

*A talk before the students of the Short Course in Ceramic Engineering at the University of Illinois, Jan. 11, 1918.

†Professor of Ceramic Chemistry, University of Illinois.

This example illustrates fairly well the condition of affairs in Great Britain in the early days of the war. These conditions have, of course, been remedied to a large extent since the war started, because English scientific unpreparedness, as contrasted with Germany's high state of scientific preparedness, was not in any way due to the fact that Germany had better chemists than England, for such was not the case; the difference was due to the fact that the German government and people appreciated the importance of scientific education, scientific research, and the application of science to industry, while the British government and her people did not.

But to return to the subject of ceramics and the war. In addition to the problems of chemical glassware and of heat-resisting glass already mentioned, one other glass problem of still greater importance had to be solved. I refer to the matter of optical glass, about which we have heard a great deal since our own country entered the war. Optical glass, as you know, is needed for the manufacture of telescopes, binoculars, officers' field glasses, range finders, and telescopic sights for the artillery, submarine and trench periscopes, photographic lenses and photographic plates for army and navy observation purposes, and X-ray bulbs and microscopic lenses for the medical and sanitary corps. Previous to the war, Germany manufactured about 100 different kinds of optical glass, which she shipped to all parts of the world. England manufactured about 20 different kinds, and the United States manufactured none whatever. The twenty kinds manufactured by England were not sufficient in number, nor was the output anywhere near sufficient to supply the British army and navy. In fact, in addition to stimulating the manufacture of optical glass the British government was obliged to collect from private individuals large numbers of field glasses and small telescopes, and even as recently as six months ago the output of optical glass, although many times greater than it was before the war, was still apparently insufficient to provide for all of the glasses needed by the army and navy.

When America entered the war she was, as you know, also brought face to face with this same problem in ceramic chemistry, and the country was obliged to turn to its chemists for assistance. Under the able direction of a special committee on optical glass, composed of Major H. A. Millikan, professor of physics at the University of Chicago; Dr. Arthur L. Day, director of the Geophysical Laboratory of the Carnegie Institution; and Dr. S. W. Stratton, director of the U. S. Bureau of Standards, research in the manufacture of optical glass has been vigorously prosecuted both in the Geophysical Laboratory, under Dr. Day's direction, and in the Bureau of Standards' Laboratories at Pittsburgh, under the direction of Mr. A. V. Bleininger. As a result of these investigations, and with the co-operation of some of the largest glass manufacturers of the country, there is now being manufactured in America all of the different kinds of optical glass which are most urgently needed by the army and navy; and although the output is, as yet, not quite as large as we would like to have it, the situation is improving every day, and the crisis with which the country was threatened may be considered as safely past. In fact, there seems to be no likelihood that the glass situation, as a whole, will ever become as acute in this country as it did in England, where a special officer having the title of Director of Optical and Glassware Munitions was appointed and placed in charge of all glass production, purchase and sale in the United Kingdom. No kind of glass or glassware can be manufactured, bought or sold in England without a license from this officer.

The second big field of ceramics which is of fundamental importance to the industrial life of a nation, both in time of war and in time of peace, is the field of refractory materials. Every industry which uses high temperatures in any part of its process has a more or less acute problem of refractory materials. Even where the only high temperature employed is in the power house of the plant there still exists a rather important ceramic problem, for the life of a boiler setting depends upon the proper adaptation of the refractory material employed to the chemical action of the fuel gases and to the abrading action of ashes and cinders, as well as to the direct action of the high temperature itself. In industries such as the metallurgical industries, which employ very high temperatures, the problem of refractory materials is, of course, of still greater importance. In fact, it is not too much to say, that, other things being equal, the rate at which a country can produce munitions of war is very closely connected with its supply of suitable refractory materials because the character of such materials determines the frequency with which furnaces have to be closed down for relining. A great many refractory materials, such as fire brick and other fire-clay articles, silica brick, chrome brick, magnesite brick, dolomite, bauxite, graphite, porcelain, alundum, zirconia, etc., are manufactured and employed in the different industries, each industry having its own special refractory problems, since the conditions of temperature, chemical action, abrasion, etc., are different in the different industries, and the refractory has to be adapted to withstand the special conditions of each industry.

Among the porcelain refractories may be mentioned the special electrical insulators for high-tension transmission lines, as well as the insulators for ordinary voltages in buildings, cars, and on ships; sanitary porcelain; the porcelain employed by the chemist in the form of crucibles, casseroles, etc.; the particular variety of porcelain used in protecting pyrometer tubes; and the porcelain spark plugs which are so important in the aeroplane. Indeed, the length of time which an aeroplane can remain in the air is not infrequently determined by the character of its spark plug, since an improperly constructed spark plug deteriorates rapidly under the influence of the high temperatures to which it is subjected during the operation of the engine. We thus see that ceramics has an important and close connection even with the subject of aviation. In the case of chemical porcelain and the special porcelain for manufacturing pyrometer tubes, the ceramic chemists of this country have had to discover the methods of manufacturing these materials, since they were purchased from Germany previous to the war. Fortunately, the investigations of our ceramic chemists on these two subjects have been entirely successful, and we can manufacture, and are manufacturing, porcelain of this character which is just as good, if not better, than that which was previously imported from Germany. Among other ceramic products which are more or less important in time of war the following may be mentioned:

1. Enameled iron products, such as autoclaves, kettles, and evaporators, which are used in ammunition manufacture. The manufacture of an enameled lining which will stand up under the pressures, temperatures and chemical action to which it is subjected in these processes is quite a problem. The less important application of enameled ware, in the form of cooking vessels in the army canteens and kitchens, may also be mentioned.

2. The manufacture of abrasive wheels, of which large numbers are used in the manufacture of artillery, is an important ceramic industry, and the proper bonding material for use in the manufacture of such wheels is a ceramic problem which still requires considerable investigation.

3. The purification and treatment of ceramic raw materials, such as clays, sand, bauxite, etc., in order to adapt them for the needs of the manufacturer, is also one of the most important ceramic subjects at the present time.

The foregoing outline of ceramics and its relation to warfare will serve, I hope, to convey a general idea of the many and varied ways in which the ceramic industries of the country are of fundamental importance to the nation's welfare and to its ability to properly prepare itself for war. The need for scientifically trained ceramic chemists and ceramic engineers has never been so great as it is at the present time. The country could easily absorb ten times as many technically trained men of this character as it is now producing, and it ought to be the duty of every man who appreciates the situation to do everything he can to stimulate the production of such men. I think one of the reasons why so few college men take up ceramics as a life work is because of the ignorance on the part of the general public as to the significance and importance of this subject, and I hope that each one of you will make it a point to call the attention of the young men in your own community to the importance of this field and to the excellent prospects which it holds out to a young man who will properly train himself in this subject. There ought to be a very rapid growth in all of the ceramic schools of the country during the next ten years, but I am certain that even the most rapid growth which we are likely to have will still fall far behind the still greater growth in the demand for such men, because of the fact that the great ceramic industries of the country, employing thousands of men, and representing an investment of many millions of dollars, are just beginning to wake up to the importance of applied science and to the necessity of employing technically trained men for directing their operations and solving their difficulties.

Great as is the present demand for such men, I am sure that in the next decade we are going to see this demand multiplied manyfold, and I hope that every one of you will on every possible occasion make known to the young men of your acquaintance the excellent prospects which the career of ceramic chemist and ceramic engineer holds out to them.

Nichols Medal Award—The jury of the Wm. H. Nichols Medal of the New York Section of the American Chemical Society awarded the medal for the calendar year 1917 to Treat B. Johnson of the Sheffield Scientific School of Yale University, for his work on pyrimidines.

Sulphuric Acid Production in 1917

More sulphuric acid was produced in the United States in 1917 than in any previous year, according to the Geological Survey. A moderate estimate shows that the increase in the production of acid of all strengths in 1917 over that in 1916, stated in terms of 60-deg. B. acid, amounted to at least 600,000 tons.

It is not yet possible to state accurately the production of sulphuric acid in 1917 according to strengths, for some of the companies that produce 50-deg, 60-deg. and 66-deg. acid have reported their entire production together and so stated it as if they had made only 100 per cent acid. Now, 100 per cent sulphuric acid is above 66 deg. B. and is here reported as "stronger acid," but, in view of the fact stated, a certain quantity of the stronger acid reported should really be carried as acid having a strength of 66 deg. B. or less. However, as no data are available to show the proper distribution of all the acid made in 1917, the following table has been prepared as if the reported production were the actual production:

Strength of Acid	1917 Short Tons	1916 Short Tons
50 deg.	2,306,372	1,829,471
60 deg.	1,187,704	1,119,753
66 deg.	850,006	1,580,100
Stronger acid	1,190,019	443,332

In comparing the production reported for 1917 with that for 1916, only acids of similar strength should be compared. For instance, the amount of acid of 66 deg. B. reported for 1917, namely, 850,000 tons, is equivalent to 1,290,000 tons of 50-deg. acid. In other words, the sum of the amounts of the different acids as given above for 1916 and 1917 should not be compared to show the output in the two years, for the great increase in the output of the stronger acids would represent a much larger increase in that of the weaker acids.

The condition of the market for sulphuric acid in 1917 is reported to have been on the whole even better than in 1916, and the value of the product was considerably higher than it was during that year of high prices. Some companies have had difficulty in obtaining sufficient sulphur ore and many of them have been compelled to change from pyrite to sulphur burners. Experiments in the greater utilization of pyrrhotite have been carried on and attempts have been made to find domestic deposits of pyrite that can be used if the supplies of foreign ore are curtailed under the conditions imposed by the war.

Nearly 98 per cent of the manufacturers reported their production, and that of the others was estimated from previous records. It is believed that the totals of these preliminary figures will approximate very closely the final figures, which will be made up when the complete returns are received, although the quantity of acids of different strengths as stated may require considerable readjustment.

Red Cross Wants Used Tracing Cloth.—The American Red Cross is desirous of having manufacturers, draftsmen and all those having old tracing cloth which is of no value to them send it to a local laundry or Laundry Owners' Association, where it will be washed and delivered to the Red Cross. An appeal has been made to laundries to undertake the work and it is felt that considerable linen, of which there is a shortage, can be furnished in this way.

The Trumble Oil-Refining Process

AT the annual meeting of the American Institute of Mechanical Engineers, in December, N. W. THOMPSON of the Simplex Refining Co. of San Francisco presented a description of a new oil-refining process known as the Trumble process. The chief advantage claimed for the process is the conservation of heat. It was stated that a plant operating under this system was doing—on 1.1 per cent of the crude oil run through as fuel—more work than large oil refineries using as fuel 4 per cent of the crude oil.

In Fig. 1 is shown a Trumble evaporator, to which in this case is connected an evaporator column. The evaporator consists of a closed cylindrical metal shell, vertically disposed, to which heat is applied from the outside in any convenient manner, as, for example, by flue gases or by vapors from another evaporator.

Inside the evaporating chamber is arranged a central vertical pipe having umbrella-shaped devices attached

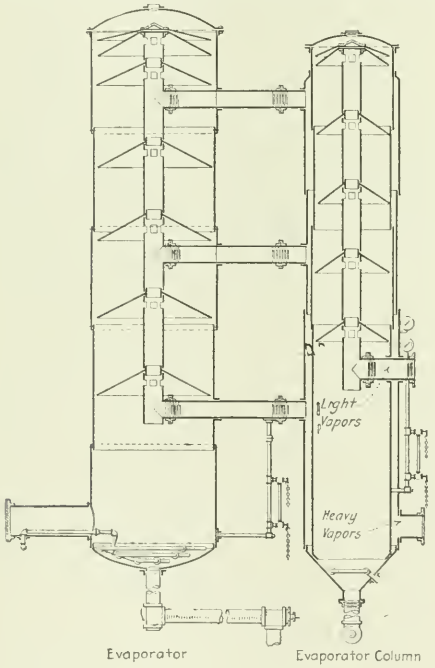


FIG. 1. EVAPORATOR AND EVAPORATOR COLUMN

thereto at intervals, which are called "spreader hoods," so that oil fed to the apex of these hoods will flow down over their sides in a thin film after the analogy of rain flowing down the outside of an umbrella. The lower edges of these hoods are at a little distance from the sides of the wall of the evaporating chamber, and in operation the oil flows down and over the hood and strikes against the interior wall of the evaporating chamber and flows down the wall in a thin continuous film.

In case any of the oil should not strike against the wall in the evaporating chamber, but should drop off the edge of the hood and fall vertically; or in case there should be a tendency to bubbling or foaming on the wall of the evaporating chamber whereby a portion of the oil may be thrown back toward the center of the evaporating chamber, such oil will be caught by the next spreader hood and will flow down the surface thereof, thereby insuring an ultimate spreading of the oil on the wall of the evaporating chamber.

The oil to be operated on is fed through a supply pipe to the top of the evaporating chamber, and discharges downward on the apex of the uppermost hood. The oil then flows down this hood in a thin stream, and is delivered against the interior wall of the evaporating chamber as herein above described.

The centrally arranged vapor take-off pipe in the evaporating chamber, to which the spreader hoods are attached, is provided with perforations underneath each of the hoods, and through these perforations the vapors pass from the evaporating chamber into the vapor take-off pipe. Located in this vapor take-off pipe are lateral branch pipes, and these branches extend through the wall of the evaporating chamber to the outside of the apparatus.

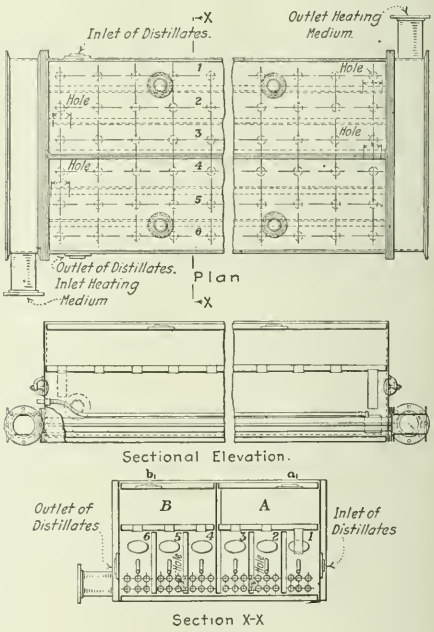


FIG. 2. SEPARATOR

Fig. 2 shows the construction of the separator. This is a re-run still for distillates from bottoms of dephlegmators, or from any other source, if these need fractionating. The distillate flows into compartment (1) over a number of pipes through which a heating medium is passed, either residuum or vapors, as the case may be, and then passes through an opening at end of compartment (1) into compartment (2) and back through compartment (3) and so on, leaving at the end of compartment (6). The vapors evolved in compartments (1), (2) and (3) pass through openings into vapor compartment *B* and out through opening b_1 to condenser, etc.

The manifolds on the ends of the separators are pro-

vided with covers having stuffing boxes through which valves are operated to regulate the flow through tubes in each compartment, thereby controlling the heat in these compartments.

The flow of the crude oil through the plant is indicated by the flow sheet in Fig. 3. The oil enters through a 6-in. line and is used as a cooling medium in the six coolers shown. These coolers are of the horizontal tubular type, 30 in. in diameter, with sixty-two 2-in. by 18-ft. tubes. The oil enters at the bottom and passes through the tubes, making four passes, and comes out at the top and goes into a header, through which it passes into the four heat exchangers or coolers for the residuum.

These heat exchangers are 48 in. in diameter, and have 178 2-in. by 18-ft. tubes. The crude oil enters the first heat exchanger at the bottom and passes through the tubes, making six passes, and out at the top into the bottom of the next exchanger, and so on, to the heater pipes, where it is split in two, each half passing in series through seventy-two $18\frac{3}{4}$-ft. lengths of 4-in. pipe, flowing back and forth and upward at all times, and then into the top of the evaporator, where it flows down the sides in a thin film.

The oil, in passing through the heater pipes and evaporator, is heated by the flue gases. The vapors evolved are separated in the evaporator and taken care of later. The oil is maintained at a constant level in the bottom of the evaporator and runs out of the bottom of it as residuum. A perforated steam coil is placed in the bottom of the evaporator under the liquid and superheated steam is passed through it in order to drive off any of the lighter distillates which may drop back from the vapors. However, very little steam is necessary in this case, as the heat losses are supplied by the flue gases.

After leaving the evaporator the residuum is used as a heating medium for redistilling the distillates passing through separators, and then flows through the heat exchangers counter-current to the crude oil. The residuum enters the first heat exchanger at the top and makes two passes around the tubes and out at the bottom, then into top of the second exchanger, and so on through the five heat exchangers and through a standpipe, which is vented, and which controls the head of residuum in the bottom of the evaporator, and then to the storage tanks.

The vapors from the central vapor column of the evaporator are taken out through a shell and connected into a header. The vapors pass from this header through an oil catcher similar to a steam separator, the condensate passing out of the bottom of it into the bottom of the evaporator. They then pass through six large dephlegmators in series, flowing into the bottom of each and out at the top. In each dephlegmator a partial condensing of the vapor takes place, thus forming a liquid in the bottom of that particular dephlegmator. From some of the dephlegmators this condensed liquid is a ready product—from others it is just between two different products.

A system of water circulation is used as a cooling medium for the vapors from the dephlegmators and separators. The vapors are cooled in vertical tubular condensers, and about twenty barrels of water are required per barrel of distillate cooled. Superheated steam is used in the bottom of the evaporators, separators and dephlegmators as an agitator to relieve the lower boiling point fractions from the bottom. About 30 lb. of steam are used to each barrel of distillate produced.

Mr. Thompson said it is possible to save by proper distribution of the heat available around the oil refineries in the United States at least 2 per cent of the total crude oil put through these refineries. He said there are large oil refineries operating to-day that are using as fuel 4 per cent of the crude oil run through them to do less work than the plant described is doing on 1.1 per cent of the crude oil run through as fuel, and the losses due to non-condensable gases, etc., are 2 per cent against 0.75 per cent.

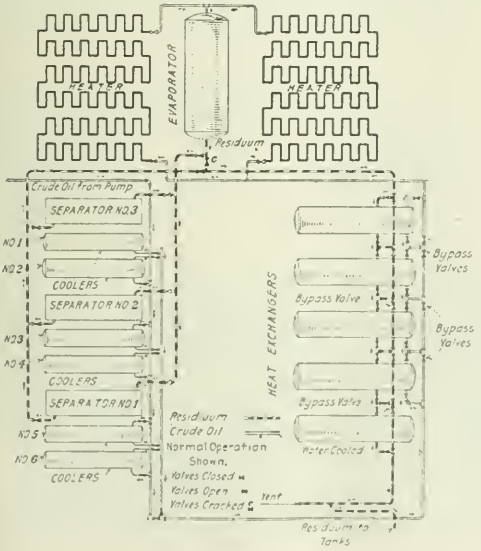


FIG. 3. CRUDE OIL AND RESIDUUM SYSTEM

Cost of Refining Gasoline.—The Federal Trade Commission has obtained data on the cost of producing gasoline in August, 1917. The figures are the result of distributing the actual total refinery costs to the various refined products on the basis of the values of the various products. The costs are based on 55 refineries in all parts of the United States. They are given in the following table:

REFINING COST PER GALLON OF GASOLINE

	Low Cents	High Cents	Representative Cents
1—NEW JERSEY AND EASTERN TERRITORY			
Cost of crude oil	12.0784	13.9575	12.7348
Cost of refining	2.0271	3.9570	4.8836
Total	14.1055	17.9145	17.6420
2—INDIANA AND NORTH MISSISSIPPI VALLEY			
Cost of Crude oil	9.8212	12.8827	11.5120
Cost of refining	1.3620	3.8621	2.1630
Total	11.1840	16.7448	13.6750
3—OKLAHOMA			
Cost of crude oil	9.8801	15.2620	11.1860
Cost of refining	1.5196	2.3740	3.4856
Total	11.4000	17.6360	14.6706
4—GULF COAST			
Cost of crude oil	11.5670	14.5774	13.6608
Cost of refining	.8520	1.7579	1.8074
Total	12.4190	16.3353	15.4682
5—CALIFORNIA			
Cost of crude oil	9.8683	12.2033	11.7160
Cost of refining	1.8743	4.3112	1.7800
Total	11.7426	16.5145	13.5200

Plate-and-Frame Filtration

By D. R. Sperry

FILTRATION within a filter-press may be carried on by means of plates and frames.

Flush Plates

In Fig. 1 is shown a filter plate which can be used only with frames. It will be noted that this kind of plate appears somewhat like the recessed type. The feed-channel is formed by an eye in the upper corner, but is plainly not to be used with grommets. Fig. 2 shows this plate in cross section. Here it can be observed that there is practically no recess in the surfaces whatever and that the hole in the upper corner, called an eye, is much smaller in diameter than that found in the recessed type of plate. The surface surrounding the hole is also flush with the packing surfaces of the plate and has no connections with the filter surfaces or interior of the plate. The grooves on the filtering surfaces lead directly to the outlet, precisely as is the case in the recessed plate. This plate is distinguished from the recessed type of plate by the name of "flush plate."

Frames

In Fig. 3 is shown a frame used in conjunction with the flush type of plate. In general this consists of a flush plate without a center panel. In other words, if the center of a flush plate be cut away up to the packing surfaces, it would have the same general appearance as a frame. In Fig. 4 a frame in cross-section is shown Especial attention is called to the fact that the corner eye has a connection to the interior of the frame and does not go merely straight through from packing surface to packing surface as is the case in a flush plate.

Clothing

In order to use a flush plate-and-frame filter-press, the plates and heads are first clothed. To do this cloths are cut for each plate which are long enough to lay over the top of the plate and extend over each filter surface and beyond the packing surfaces. A hole is cut in the cloth where it covers the eye in the plate. A cloth cut and ready to be applied to a flush plate is shown in Fig. 5.

FIG. 1 FIG. 3 FIG. 5

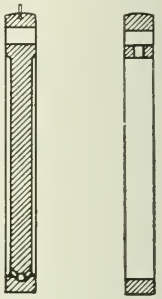


FIG. 2 FIG. 4

A photograph of a cloth in position over a flush plate, but partly lifted to show plate surface, is given in Fig. 6. Two locating pins are placed on the top edge of each plate by means of which the filter cloth is held in position and kept from falling. These are called dowel pins.

Clothing the Heads

When the plates are thus clothed it is necessary to cut smaller cloths to place over the filter and packing surfaces of the heads. The cloth on the slide head has no hole cut in it, as none is required. The one on the fixed head, however, has a hole cut in it where the cloth covers the inlet eye. Photographs of slide and fixed heads showing how the cloths are applied are shown in Fig. 7 and 8. It should be understood

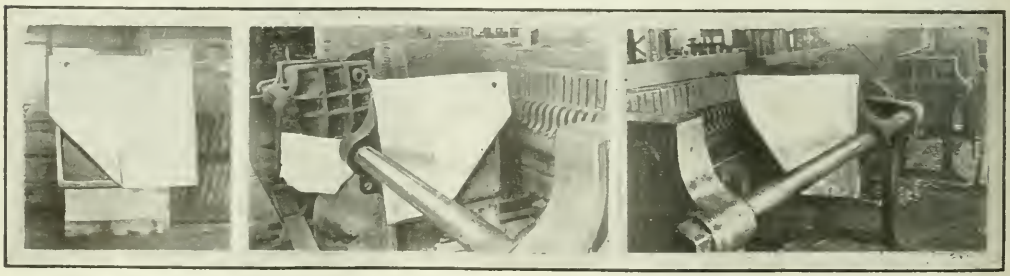


FIG. 6 FIG. 7 FIG. 8

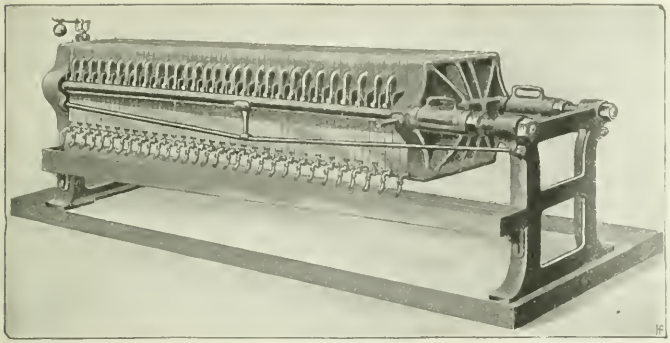


FIG. 9

that dowel pins are supplied on the upper edge of the heads to hold the cloths in position.

Principle of Operation

When all of the plates and both heads are clothed, the plates and frames are placed within the filter-press alternately, that is, a frame is placed between each

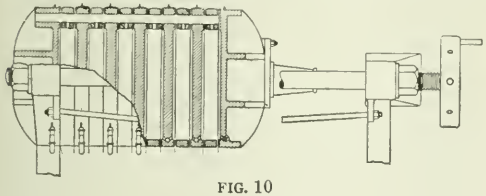


FIG. 10

pair of plates and betwen plates and heads. Thus there is always one more frame than there are plates. A filter-press of the flush plate-and-frame type with all the plates and frames in position is shown in Fig. 9. The plates can be easily distinguished from the frames by the cocks which are on the plates only.

The eyes in the plates and frames are so located that

FIG. 11

when they are in the filter-press they register with each other, beginning with the eye in the fixed head. In other words, if one were to look in the feed inlet on the fixed head, it would be found that a continuous channel is formed by the eyes, running the whole length of the filter-press. Tapping into this channel would be, of course, the connections leading to the interior of the frame.

A cross-section of a flush plate-and-frame filter-press when fully clothed is shown in Fig. 10. Here the channel formed by the eyes in the plates and frames is clearly discernible. The connections or ports to the interior of the frames are plainly evident and their purpose can be soon understood. When the filter-press is closed the material to be filtered is introduced into the feed inlet. The substance runs the entire length of the filter-press, stopping at the slide head, where the absence of an eye therein prevents further progress. As the material flows along the channel it drops into the interior of each frame, eventually completely filling the same. When this happens there is no way for anything to escape except through the cloth. The liquid does the latter and upon emerging on the opposite side of the cloth is conducted along the grooves of the plate surface directly to the outlet corner and out via the cocks. The solids, unable to pass through the cloth and the accumulated

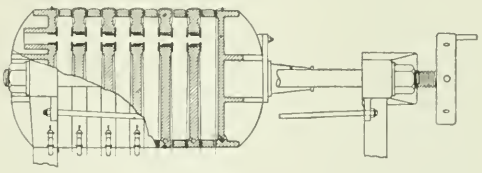


FIG. 12

solids, are retained within the frame. Eventually the frame becomes completely filled with solids and the filter-press is said to be filled. When this has occurred, the material to be filtered is no longer fed into the filter-press and the screw of the filter-press is loosened. The slide head is then pulled back as far as it can go and the adjacent frame slid up and cleaned of its contents of cake. The first plate is then drawn up and the next frame cleaned, and so on, until all of the frames are relieved of their contents. When this is completed, the empty frames and plates are slid back into their proper positions for the next fill.

Frames With Grommet Feed Plates

Frames having no eyes whatever can be used in conjunction with plates having the grommet type of feed. Such a frame is shown in Fig. 11. It can be readily understood how a frame of this type could be inserted between plates of the recessed type and have the effect merely of increasing the cake thickness or chamber capacity. In case the plate were not made recessed but flush, still retaining the grommet feed, the eyeless frame could still be placed between adjacent plates and form a chamber in a somewhat similar manner to that done in the flush plate-and-frame type. A cross-section of a grommet flush plate-and-frame filter-press is shown in Fig. 12. The plates, frames and heads are clothed in a manner similar to that described for the recessed type of plate. A study of Fig. 12 shows that a channel from end to end of the filter-press is formed

by the grommets and the interior of the frames. The end of the channel is formed by the slide head, which has no grommet hole. When the material to be filtered is fed into the inlet, it runs the full length of the filter-press through the grommets and frames. In so doing it fills the interior of each frame. The pressure exerted upon the material by the pump or whatever feeding device is employed, causes the liquid to flow through the cloth which bounds each frame, onto the plate surface back of the cloth and thence via the grooves to the cock placed on the lower corner. The manner of opening and cleaning the filter-press is similar to that described for the flush plate-and-frame type.

Batavia, Ill.

Synopsis of Recent Metallurgical and Chemical Literature

Absorption of Gold in Bone-Ash Cupels.—F. P. DEWEY presents the results of four years' observations at the mint, in a paper entitled "Bone-Ash Cupels," to be presented at the February, 1918, meeting of the American Institute of Civil Engineers. In all, about 100 varieties of bone ash have been tested, and probably 10,000 or more used cupels have been assayed. The result of this investigation is a most emphatic warning against drawing conclusions regarding cupels and cupellation from insufficient data. From the vast accumulation of data now on hand, I can pick out isolated illustrations here and there to support any reasonable supposition and also a great many unreasonable and contradictory ones regarding the subject. Again I can pick out many apparent exceptions to every general rule.

The second result is to emphasize the difficulty of carrying on several sets of cupellations under even approximately the same conditions.

The third result is that rigid conclusions regarding bone ash, cupels and cupellation call for such a vast amount of painstaking detailed work under such onerous conditions that the game is scarcely worth the candle, especially as the customary variations occurring in practical work will nullify many such conclusions.

Finally, then, the results of this work cannot be dealt with in any dogmatic way, but they must be applied in a general and practical way with reasonable consideration and caution.

There have been many investigations of cupels and the most diverse views have been expressed, the extremes being the statements of Lodge[1] that every cupel has some effect upon the loss in assaying telluride ores and of the Campredons[2] that coarse and fine and hard and soft cupels all give the same loss of silver when cupelling the same weights. The truth lies between these statements and much nearer the latter. In a vast majority of cases the influence of the cupel is not dominant and is outweighed by other conditions, particularly the temperature of the cupelling bead.

[1]R. W. Lodge: Assaying Telluride Ores for Gold. *Technology Quarterly* (1899), 12, 171.

[2]G. Campredon: Importance des différentes causes de pertes d'argent à la coupellation. *Revue Universelle des Mines*, Ser. 8 (1904), 8, 210.

In following this matter up, for the purpose of increasing the accuracy of our commercial methods of bullion assays, the question of the absorption of gold by the cupel was found to be a most important one and was taken up for investigation. In a lesser degree, the silver absorption is important and interesting, but at present it appears to be far more complicated and much further investigation is required to put the subject upon a satisfactory basis.

In assaying high-grade products giving large assay buttons, the following general conclusions may be drawn: Within wide limits the screen composition of the bone ash is not the dominant factor in cupellation, but the assayer should inform himself as to the grades of ash available and adopt some plan in selecting or mixing his ash. In the same way the pressure used in making cupels is not highly important, although it is well to keep it fairly uniform. There is no necessity to season cupels. In making comparative tests the closest attention must be given to the temperature question, but the temperature of the cupelling bead is for the present beyond either measurement or control, and high general temperature in the muffle may produce wide variations in the absorption of gold in adjoining cupels. The pyrometer is a good guide to the general temperature conditions, but uniformity of pyrometer reading does not mean uniform bead temperature.

In assaying ductile fine gold, for instance, it is evident that the gold absorption by a cupel may be kept down to 0.1 mg. and need not exceed 0.2 mg. Certainly an absorption of over 0.25 mg. should not be countenanced in fine-gold assaying. In the case of coin gold the figures might be increased by 0.05 mg.

The careful assayer should establish standards of cupellation suitable for his particular lines of work and should assay his used cupels from time to time to see that the standards are being maintained. The conditions of the cupellation are far more important in influencing the cupel absorption than the structure of the cupel. When high or erratic losses are shown the used cupel should first be examined for beads. In the absence of beads the other conditions, especially the temperature, should be carefully considered before blaming the cupel.

Iron and Steel

Copper in Medium Steel.—C. R. HAYWARD and A. B. JOHNSTON have presented a paper before the New York meeting (1918) of the American Institute of Mining Engineers on "The Effect of the Presence of a Small Amount of Copper in Medium-Carbon Steel." Two analyses were investigated, as follows:

	High Copper	Low Copper
C	0.380	0.365
P	0.012	0.053
Mn	0.570	0.590
S	0.030	0.048
Cu	0.860	0.030

The bars, turned to ¾ in., were heated to 845-865 deg. C., quenched and drawn in various ways. The unannealed bars were too hard to turn on a lathe. A 7-in. length was therefore used and the ends annealed in a blacksmith's forge to allow the cutting of the threads. During the heating, the center was kept cool

with water. A 2-in. gage length was then ground at the center of the bar.

The results as shown in Fig. 1 and the accompanying table needs little interpretation. The table of tensile strengths shows a striking superiority of the high-copper steel. The yield point and ultimate strength are in every case higher while the ductility is practically the same, although here too the average figures for reduction of area are with one exception slightly higher for the high-copper than for the low. This, however, is offset by slightly higher values for elongation in a majority of the tests in favor of the low-copper.

The hardness tests by both methods show the high-copper steel in all tests to be harder than the low-copper.

The Charpy shock tests show the high-copper steel in all cases to be superior to the low-copper.

In general, the results confirm the work of Ball,[1] Stead,[2] Breuil[3] and Campbell[4] as regards the effect of copper on hardness and tensile strength. They confirm the work of Breuil[3] as regards brittleness and the work of Campbell[4] as regards reduction of area. It is also true, that as Stead has stated, the behavior of the copper steel resembled that of nickel steel.

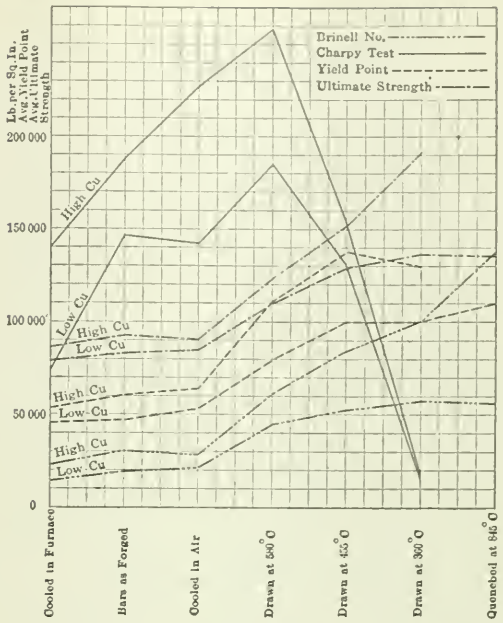


FIG. 1. RESULTS OF TESTS OF STEEL WITH DIFFERENT COPPER CONTENTS

	Per Cent. Reduction		Per Cent. Elongation	
	High Cu	Low Cu	High Cu	Low Cu
Cooled in furnace.	49.0	46.2	26.0	26.7
Cooled in air.....	52.7	52.7	27.3	27.3
Bars as forged	52.7	50.9	24.8	25.8
Drawn at 580° C.....	56.3	54.6	32.2	32.7
Drawn at 455° C.....	50.0	49.0	27.8	18.0
Drawn at 360° C.....	39.1	40.2	9.2	12.8
Quenched at 825° C....	...	20.5	...	6.5

Acid-Proof Alloys.—An interesting investigation was recently recorded in *Metall und Erz* by ROLAND IRMANN, according to the *Chemical Trade Journal and Chemical Engineer.*

It is often asserted that electrolytic corrosion tests of voltaic couples of two metals should be a guide as to the corrosion of the alloys of those metals. The investigation by Dr. Roland Irmann of alloys of copper and nickel, to which tungsten and iron were further added, once more disproves this assumption. Much depends upon the proportions and the formation of compounds. Irmann (*Metall und Erz*) was in search of an alloy not to be attacked by strong hot sulphuric acid. He found that an alloy of nickel with 20 per cent of tungsten was much more resistant in this respect than nickel alone; but that the alloy was very difficult to machine and expensive. To introduce tungsten into the nickel, he started from copper-nickel. A voltaic couple of nickel and copper gave an electromotive force of 0.55 volt, which soon went down to 0.25 volt; nickel was dissolved, the copper becoming polarized with hydrogen. Failing to find a more satisfactory binary nickel-couple, he introduced other elements, especially tungsten, into the nickel-copper alloys, studying also the alloys of copper and tungsten. He fused an alloy of nickel-tungsten in an arc furnace and added electrolytic copper; later he used a Helberger furnace, afterward adding more nickel as required. The alloy, consisting of 47 per cent of copper and 4.98 per cent of tungsten, proved highly resistant, and, at the same time, mechanically very strong, giving also the greatest elongation of these copper-tungsten alloys. The electric resistance was greater than that of constantan. Very good results were also obtained with ternary nickel-tungsten-copper alloys. The interesting point is, however, that quarternary alloys, further containing iron, proved far superior to the ternary alloys. This is important in so far, of course, as one may, in preparing the alloys, start from ferro-tungsten instead of having to isolate the tungsten first. By varying the percentage of iron—always low—the qualities of the alloys were suitably modified. When the sulphuric acid is to be used in the cold only, one should take alloys relatively rich in copper and also, to a minor degree, in tungsten and iron. For hot concentrated sulphuric acid Irmann recommends a nickel alloy with 43.65 per cent of Cu, 3.9 per cent W, 1.87 per cent Fe. This alloy also has a very high electric resistance and strength, and can easily be machined; the tensile strength was 28 tons per square inch, and rose to 35.05 tons per square inch in an alloy containing 3.9 per cent of iron. Some of the alloys, however, rather tended to separate in layers during fusion. Irmann also tried to improve German silver (60 per cent Cu, 20 per cent Ni, 20 per cent Zn) by the introduction of tungsten. But the tungsten would not alloy with the zinc, and he could not get more than 0.4 per cent of tungsten into this ternary alloy; the quaternary alloy was, moreover, badly attacked by sulphuric acid.

[1] E. J. Ball and A. Wingham: On the Influence of Copper on the Tensile Strength of Steel. *Journal of the Iron and Steel Institute* (1888), I, 123-131.

[2] J. E. Stead and J. Evans: Influence of Copper on Steel Rails and Plates. *Journal of the Iron and Steel Institute* (1901), I, 89-100.

[3] P. Breuil: Copper Steels. *Jonrnal of the Iron and Steel Institute* (1907), II, 1-78.

[4] *Manufacture and Properties of Structural Steel*, N. Y. Scientific Pub. Co., 1896.

Recent Metallurgical and Chemical Patents

Roasting and Sintering Apparatus

Combined Sintering and Smelting.—ARTHUR S. DWIGHT of New York City patents a process of sintering and smelting ore which consists of the formation of a continuous sinter cake on the well-known Dwight-Lloyd machine, and continually moving the cake through a slot into a furnace set immediately alongside. By submerging the inner end of the sinter cake into the contained bath its tendency to break by its own weight is counteracted. As the cake enters the furnace it slides between suitable electrical contacts. A sufficient voltage is impressed on the system so that electric current passes through the sinter cake, slag, metal, and furnace bottom to the opposite terminal. The cake is thus heated in four ways: By the heat of sintering, by the current passing through the cake, by conduction and radiation from furnace and contents, and by the arc at the end of the cake. The end of the advancing cake is thus continually melted off, metal, matte and slag separated, and withdrawn. (1,215,635, Feb. 13, 1917.)

Chloridizing Roast for Spent Pyrite.—EDGAR R. SUTCLIFFE of Leigh, England, patents a method for treating ores or residues of especial application to the process of converting copper contained in spent pyrite into cupric chloride for subsequent extraction by wet methods. The ore, together with sufficient common salt, is introduced into a cylindrical kiln *a* through a hopper *f*, and heated to a temperature of 600 to 700 deg. C. by a gas

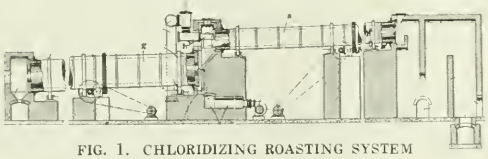


FIG. 1. CHLORIDIZING ROASTING SYSTEM

flame maintained at the nozzle h^3, at the lower end. Passage of the first kiln requires but a short time (from 30 to 40 minutes), during which the greater part of the metal to be recovered is chloridized. The heated mixture is discharged directly into the larger kiln *g*, where the same reaction is continued for a much longer time (3 to 8 hours), during which time elevated temperature and continuous agitation is maintained. This allows the final discharge to be almost completely converted. (1,245,634, Nov. 6, 1917.)

Sintering Blast Furnace Flue Dust.—A. J. BOYNTON of Lorain and A. E. SANDS of Akron, Ohio, have patented an improved method of sintering fines in pans having porous hearths. The usual process involves placing a layer of fines on a layer of crushed refractory protecting the grate bars. An igniter is then put into position above the pan, and an exhaust fan connected to the air box under the grate bars draws the products of combustion down through the mass of fines until the upper surface is burning. The igniter is then removed, the fan continues to draw air through the mass, thus gradually extending the combustion and agglomeration down through the entire mass. The results depend upon close control of the amount of combustible present in the fines, too much carbon resulting in the formation of liquid cinder which trickles down, plugging the interstices in grate bars and porous hearth, superheating the cake and apparatus, and causing non-uniform results. It is therefore necessary to consume much time in cooling the mass, thus delaying operation to such an extent that as much time is required to sinter the last 10 per cent of the material as is necessary for the first 90 per cent.

In the operation of the improved process the mixed and moistened material is spread on the porous hearth and ignited as usual. After combustion has proceeded until a hard crust has formed on top, the pan is rotated 90 deg. about air-exhaust trunions at the ends until the top surface is nearly vertical. The exhaust fan is kept running continuously, until sintering is completed; any cinder or slag which may liquidate out will trickle downward, now parallel to the porous hearth, and may be topped off by punching holes in the lower part of the cake. At the end of the process, the pan is further rotated, dropping the hot contents into a car beneath. (1,245,183, Nov. 6, 1917.)

Blast Roaster With Reciprocating Grates.—A. H. DERN of Salt Lake City and T. P. HOLT of Silver City, Utah (assignors to Holt-Christensen Process Co.), have

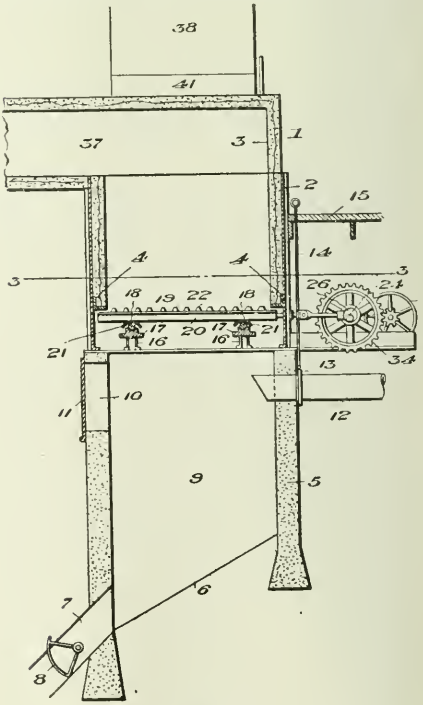


FIG. 2. HOLT-DERN BLAST ROASTER

patented improvements to ore roasters previously covered in Patents No. 1,113,961 and 2, Oct. 20, 1914. To afford a satisfactory draft without undue dust losses during charging, an inclosed rectangular roasting chamber communicates with a crosswise smoke flue (37),

and is charged through openings in the top. The grate is composed of a series of sections each made of a pair of longitudinal beams with crosswise teeth (22) at intervals on top. These may be driven independently by suitable mechanism (26) so that if the columnar roast settles more slowly in one part than in another, the first supporting grates may be operated a greater length of time. The body of the roaster rests directly upon a discharge bin (9), where the hot mass may remain for any desired period of time, which slow cooling is of advantage in chloridizing many ores. Air blast is introduced below the grates through the pipe (12), and the roasting is carried on in the manner described in the former patents. (1,251,189, Dec. 25, 1917.)

Metal Testing

Metal Sheet Testing.—The patent on the "Erichsen" metal sheet-testing machine, issued April 21, 1914 (No. 1,094,319) to ABRAHAM M. ERICHSEN of Christiania, Norway, has been reissued under date of Jan. 8, 1918 (No. 14,421). The machine was described in METALLURGICAL & CHEMICAL ENGINEERING for Dec. 15, 1916, p. 709.

Electric Furnaces

Two-phase Arc Furnace.—C. H. VOM BAUR of Douglaston, N. Y., has patented a two-phase arc furnace of the form illustrated in Fig. 3. Since in the two-phase, three-wire arrangement shown the central electrode carries $\sqrt{2}$ times the current in the lateral ones, the center of the furnace will be hotter, thus aiding in smelting down a fresh pile of ore and increasing the circulation in the molten bath. The side walls are dimensioned as shown so that overheating is avoided, all points receive approximately equal radiation. All electrodes are adjustable vertically; in addition the lateral electrodes, by means of spherical plug *F* and asbestos gaskets *G*, may be pointed toward any cold spot at the sides of the furnace. Flaming arcs are not desired, as being detrimental to the side walls and roof. The large area of slag-metal interface is of advantage in steel refining, and it is also claimed that the electrode arrangement gives a more steady current, fewer surges on the supply system and more uniform heat than a four-electrode, two-phase layout. (1,252,633; Jan. 8, 1918.)

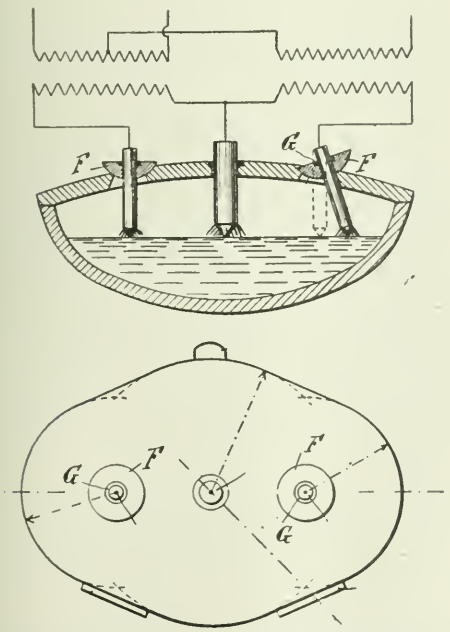


FIG. 3. PLAN AND ELEVATION OF TWO-PHASE ARC FURNACE

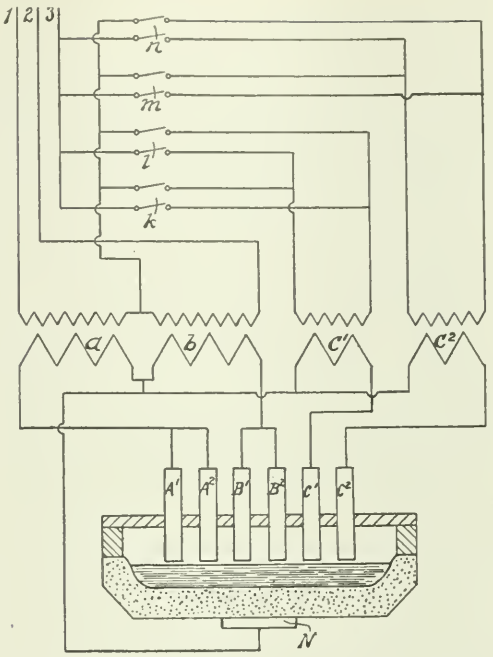
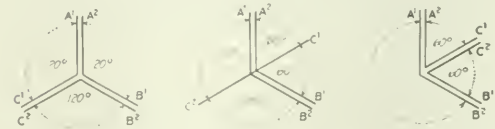


FIG. 4. WIRING DIAGRAM FOR HEAT CONTROL

Polyphase Arc Furnaces.—J. L. DIXON of Detroit, Mich., points out that advantages would acrue to the operation of arc furnaces from an electric system whereby heat could be generated either by the flaming arc, or by conduction through the melt at the will of the operator, and without an unequal loading of the supply system. He illustrates a number of wiring diagrams whereby adjustable electrodes are connected to polyphase current supply, with a lower terminal *N* connected to a neutral point, and switches in circuit to alter the phase relations of the transformers. For instance, in Fig. 4, with switches *k* and *m* closed and *l* and *n* open, the currents occupy the positions shown in Fig. 5, and the only current flowing to the hearth is due to the difference in the secondary voltages. To



FIGS. 5, 6 AND 7. VARIOUS POSITIONS OF CURRENT

throw a large current to the hearth, open *k* and *n* and close *l* and *m;* this reverses transformer c^1, and the current is as in Fig. 6. Current as in Fig. 7 throws still larger currents to the hearth, and is had by reversing both transformers by changing the switches opposite to that of Fig. 5. In all cases the supply will not be unequally loaded provided each of the transformers *a* and *b* is supplying power equal to the total supplied by c^1 and c^2. (1,241,351; Sept. 25, 1917.)

Manufacture of Sodium Ferro-cyanide.—ALEXANDER R. TILLINGHAST of Solvay, N, Y., patents improvements in the process of making sodium ferrocyanide, and assigns the patent to the Semet-Solvay Co.

Sodium ferrocyanide may be formed by effecting the combination with carbonate of iron and an alkali of hydrocyanic acid gas as obtained from the gases evolved in the destructive distillation of coal. A difficulty experienced in such a process is the loss of cyanogen due to the formation, with ammonia of the gas, of ammonium ferrocyanide. The object of the present process is to obviate such loss and provide other improvements.

The ammonia constituent of the gas is first removed by absorption in water, and the gas containing the cyanogen is then scrubbed with water containing ferrous carbonate, or its equivalent, ferrous hydrate, in suspension, and also soda ash in solution in sufficient quantity to insure the alkalinity of the carbonate.

The liquor from the scrubber contains sodium ferrocyanide, which is in solution, soda ash in solution, probably all of which exists as bicarbonate of soda, a large excess of ferrous sulphide in the form of a black, insoluble sludge, and a considerable quantity of insoluble ammonium ferro-ferrocyanide due to the presence of unseparated ammonia in the gas.

In order to convert this insoluble ferrocyanide, and any other insoluble ferrocyanide that may be present, to the soluble form, milk of lime is added to the mixture, which is then boiled and allowed to settle.

After the desired reactions are effected the insoluble residue is allowed to settle out and the clear liquid is drawn off and concentrated to the point of crystallization, after which it is run into pans and the ferrocyanide allowed to crystallize out. (1,252,741, Jan, 8, 1918.)

In another patent (1,252,742, Jan. 8, 1918) Mr. Tillinghast describes a further improvement in recovering the sodium ferrocyanide already in solution. This patent relates chiefly to the treatment of the mother liquor remaining after a portion of the ferrocyanide has been crystallized out. The claim follows:

"In the process of producing sodium ferrocyanide from the cyanogen content of gas, the method of recovering from a mother liquor from which sodium ferrocyanide has been crystallized the residue of sodium ferrocyanide and caustic soda and sodium carbonate contained therein which consists in treating ferrous sulphate with the mother liquor whereby the sodium ferrocyanide is converted into ferrous ferrocyanide and the caustic soda and sodium carbonate form ferrous hydrate and ferrous carbonate forming a suspension of the ferrous ferrocyanide, ferrous hydrate and ferrous carbonate in a solution of soda ash and scrubbing cyanogen containing gas therewith in a repetition of the process, and finally treating the resulting solution with milk of lime to convert the insoluble ferrous ferrocyanide into sodium ferrocyanide.

Ohio engineering societies, comprising local and sections of national societies, held a meeting at Columbus on Jan. 29 and formed the Association of Ohio Technical Societies. The object is to bring about professional unity.

The Parker Rust-Proofing Process

AN INTERESTING rust-proofing process has been recently developed by the Parker Rust-Proof Company of America, of Detroit.

The effect of the Parker process is essentially a chemical one. The operation consists in taking metal iron or steel, thoroughly cleaning it by sand blast, pickle, or, in some cases, a soda bath. After this the cleaned metal is immersed in a chemical solution, where it remains a predetermined length of time, depending upon the nature of the metal and just what effect is to be obtained. After the metal has been removed from the solution, it is oiled with a special oil. The oil fixes the effect of the immersion and gives it a black mat finish. On articles that are to be painted the oil is not put on, but the metal is left just as it comes from the chemical bath.

According to a patent issued to Walter I. Oeschger and assigned to the Parker Co. (1,254,263, Jan. 22, 1918), the bath consists of a 1½ per cent solution of acid meta-phosphate of tungsten, molybdenum or any of the metals of the third, fourth or fifth groups. (According to G. S. Newth's "Manual of Chemical Analysis").

The acid meta-phosphate of most general application is made by placing a quantity of iron oxide, preferably black iron scale (Fe_3O_4) in a pot with sufficient phosphoric acid to form a soft paste. The iron oxide is preferabaly powdered in advance. An amount of water equal to the acid is added to keep the mass from caking, after which heat is applied and the material is stirred until a dry granular mass is obtained, which is then powdered. If desired, heat may be applied to the oxide and acid before water is added. To obtain the phosphates of the other metals, their oxides or carbonates may be similarly treated. The patent states that the bath is preferably kept at the boiling point when the articles are being immersed.

It has been found that the mixing of about 2 per cent of strontium acid meta-phosphate with the iron compound above described gives a much more uniform and harder surface when high carbon steels are treated. Practically the same good result is attained by using the same percentage of molybdenum or tungsten acid meta-phosphates instead of the strontium acid meta-phosphate in combination with the iron compound.

According to another patent (1,254,624, Jan. 22, 1918) issued to the above and also assigned to the Parker Co., the same results may be obtained by first heating the iron or steel articles to about 600 deg. F., and then subjecting them to fumes made by heating the acid meta-phosphates to a sufficient temperature. In this case the articles may be treated right in the furnace.

The tanks used in the wet process are steel with special lining and steam-heating coils attached to the side of the tank. Such an arrangement causes a constant agitation throughout the solution. Experience has taught that the best results are obtainable by a tank built up in this way. Tanks of this type are necessary to rust-proof at a low cost.

The company states that all forms of iron or steel can be processed. The finest kind of dental needles are

being treated and in the same tank large structural steel pieces, many parts more than 20 ft. long. Machined parts, castings, pressings, forgings are all handled in a similar way and the effect of the process is likewise similar in all cases. Machined parts sometimes do not require cleaning, and they are immersed at once. Smaller parts are pickled or sandblasted in a tumbling barrel, which cuts down the cost of cleaning.

The natural finish resulting from the process is a steel gray, which, when oiled, becomes a soft mat black. The surface of the Parker processed metal is stated to be exceptionally well adapted for enameling, since there is a very fine microscopic etching which helps to bind the enamel. If at any time the enamel should crack and expose a part of the rust-proofed steel, there would be no rusting set in and consequently no peeling off of the enamel.

The rust-proofed metal does not withstand every test imaginable. For instance, it will not withstand acids such as hydrochloric, muriatic, acetic, sulphuric. Again, it will not stand up against constant attack from chemical fumes, although it resists intermittent attacks. It will prevent corrosion when exposed to atmospheric attack and also in a good many cases to other extreme tests where acids are not used. Sterilizing solutions do not affect the process.

The company is operating a plant in Detroit with a capacity of 200 tons of metal a day. Plans are under way for establishing similar plants in New York, Chicago, Philadelphia, Pittsburgh, Boston and St. Louis. Licenses are issued by the company to operate under the process. It is claimed by the company that the process is 90 per cent cheaper than the original method used in England.

American Clay for Graphite Crucibles

THE manufacture of plumbago crucibles has been greatly affected by the present war. The two important ingredients in these crucibles are graphite and plastic clay. Graphite being a lubricant, is difficult to bond and requires a clay of high plasticity and adhesiveness with a high drying and heat shrinkage.

As pointed out by Mr. McNaughton of the Joseph Dixon Crucible Co. last fall in his paper before the American Institute of Metals on the crucible situation, all of the clay for crucible purposes and 95 per cent of the plumbago was imported. The clay used came almost exclusively from Klingenberg, Germany. Shortly after the war started Germany prohibited the exportation of this clay, and while crucible manufacturers had about a year's normal supply on hand they found that the demand for crucibles was rapidly increasing and their supply would last them a much shorter time.

The crucible makers hence warned their customers that the quality of crucibles made from domestic clays would be for some time an unknown quantity until sufficient service tests had been made.

Laboratories have been called upon for testing possible clays, and several clays which give promise have been found. It is usually two or three months, however, by the time a crucible is made, using this clay, and thoroughly tested out.

One interesting clay which has been produced is the so-called K-10 synthetic clay, developed at the Kraus Research Laboratories in New York and originally marketed by Chevalier & Tully of Baltimore, Md., but now handled by the Johns-Manville Co., who plan to market it on a large scale.

This clay is produced by making extractions from various clays, etc., which are so combined as to produce a fine-grained, highly plastic refractory mass having excellent bonding power. The shape of the grains must be such that the clay when moistened and dried will have high mechanical strength. Modulus of rupture tests made on this and other clays follow:

	Modulus of Rupture Lb. per Sq. In.	
	Raw	Mixed with 80% Non-Plastic Material
K-10	552	518
Klingenberg	374	381
Mississippi	507	168
H. & W.	310	67
Illinois	156	212

The following qualities are considered requisite for a good crucible clay: plasticity, adhesiveness, raw strength, density at low temperature, chemical balance, resistance to metals in fusion, high melting point, high shrinkage on drying, high shrinkage on heating and low coefficient of expansion.

Personal

Messrs. JOHN ALLINGHAM and N. H. BEATON have opened offices at 523-525 Lissner Building, Los Angeles, as assayers and chemists under the firm name of Allingham & Beaton. They expect to specialize in flotation tests. Mr. Allingham has recently been connected with the Humboldt Smelter, Humboldt, Ariz., as metallurgist. Mr. Beaton is a mining engineer and operated for several years in Canada and Mexico. He is at present manager of the Mining Department of the California Commercial Service, Los Angeles.

Dr. SAMUEL AVERY, chancellor of the University of Nebraska since 1909, has gone to Washington to serve as assistant chairman of the chemistry committee of the National Research Council, affiliated with the Council of National Defense. Dr. M. T. Bogert is chairman of the committee.

Dr. F. E. CARRUTH, formerly connected with the chemical division of the North Carolina Experiment Station, has become associated with the Schaefer Alkaloid Works, Maywood, N. J.

Prof. G. H. CLEVENGER has resigned as research professor of metallurgy at Stanford University and is now engaged in directing co-operative experimental work which is being done by the United States Bureau of Mines, Netherlands East Indies Government, Research Corporation of New York and others.

Lieut. A. W. DAVISON has been transferred from Washington to Niagara Falls, N. Y., where he is supervising chemical plant construction and experimental operation at the Oldbury Electrochemical Company.

Lieut. ELLERY K. FILES of the Gas Defense Service has been transferred from Washington to be instructor at the National Army camp at Yaphank, L. I.

Prof. D. M. FOLSOM of the department of mineralogy of Stanford University has been appointed by Mark L. Requa to be fuel oil administrator for the western states. His jurisdiction will cover Idaho, Montana, Utah, Arizona, New Mexico, Nevada, Oregon, Washington, California and Alaska.

Mr. PAUL W. FRYE, secretary and treasurer of the Laboratory Supply Company, Columbus, Ohio, has been made manager also, following the retirement from the company of Mr. Robert C. Schroth, Jr., former president and manager.

Mr. CLARENCE FULLER, manager of the Republic distillery at Curtis Bay, Md., has taken charge of the reopening of the distillery of Clark Brothers, Peoria, Ill., recently acquired, which will be devoted to the manufacture of denatured alcohol.

Dr. FRANK AUSTIN GOOCH, professor of chemistry and director of the Kent Chemical Laboratory of Yale University, will retire at the end of the present year. Professor Gooch will be succeeded by Professor Bertram Borden Boltwood, since 1910 professor of radiochemistry.

M. HENRI JEQUIER, metallurgist of the Société Minière et Metallurgique de Penarroya, and Dr. AUGUSTE HOLLARD, consulting engineer, are on a metallurgical visit to this country. The Penarroya company, which has its headquarters in Paris, and mines and works in Spain, is the largest smelter and refiner of lead in Europe.

Dr. YOGORO KATO, professor at the Tokyo College of Technology and Director of the Nakamura Chemical Research Institute in Tokyo, attended the recent annual meeting of the American Institute of Mining Engineers in New York. Dr. Kato expects to be in this country about two months on a professional visit.

Mr. H. W. KNOWLES of the New York office of the Cutler-Hammer Mfg. Co., has been transferred permanently to Washington for the period of the war. Mr. Knowles entered the service of the Cutler-Hammer Mfg. Co. shortly after graduating from Cornell University in 1912. He spent nearly five years in the shop, engineering department and sales department at Milwaukee. Since May of last year he has been connected with their New York district office, Hudson Terminal Building. The Washington Cutler-Hammer branch will have its headquarters at the Bradford, corner 18th and K streets, telephone Main 8426.

Mr. A. G. MCGREGOR of Warren, Ariz., and Mr. WILLIAM WRAITH, vice-president of the Andes Copper Mining Company, left New York City early in February for Chile, South America, where they will visit the site of the Andes Copper Mining Company's future reduction plants at Potrerillos. Mr. McGregor also expects to visit the smelter of the Cerro de Pasco Copper Corporation in Peru before his return to the United States, where he will supervise alterations and additions to their present equipment. Messrs. Wraith and McGregor expect to remain about three months.

Obituary

Mr. F. W. MATTHIESSEN, one of the pioneers in the zinc industry in this country, passed away at his home in La Salle, Ill., on Feb. 11. He was born in Germany in 1835 and was a graduate of the Freiberg School of Mines, where he formed his friendship with Edward C. Hegeler, both coming to this country together in 1856.

Their first enterprise in this country was an attempt to produce zinc from a silicate ore near Bethlehem, Pa. They were successful technically, but the company which had previously been working on it lacked funds to go on. They then went West to Missouri and made some successful experiments in smelting zinc ore, but political conditions interfered with commercial development, hence they went to Wisconsin and from there back to La Salle, Ill., where zinc smelting was definitely established by them. In 1871 the firm of Matthiessen & Hegeler was incorporated, and in 1881 a sulphuric acid plant was added. The firm became famous for its advanced metallurgical practice.

Mr. Matthiessen was for ten years mayor of La Salle and was a member of the American Institute of Mining Engineers. He was also principal owner of the Western Clock Co., makers of "Big Ben" clocks.

Mr. AUGUSTE MATHEZ, well-known mining engineer, passed away at his home in Denver, Col., on Feb. 4, Mr. Mathez was a graduate of the Columbia School of Mines and had extensive experience all over the world in the examination of properties, including China, Australia and South America. He was located for many years in Gilpin County, Colo., and was a well-known figure there.

Book Reviews

THE TECHNICAL ANALYSIS OF BRASS AND NON-FERROUS ALLOYS. By *W. B. Price* and *R. K. Meade.* Second Ed., 12 mo. (13 x 19 cm.), 376 pages, 25 cuts. Price, $3.00. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Limited.

The introductory chapter on Engineering Alloys is fragmentary and contains some questionable statements. The rest of the book is good. Thirty pages are given to describing apparatus for electrolytic analysis. The determinations of aluminium, antimony, arsenic, bismuth, cadmium, copper, iron, lead, magnesium, manganese, nickel and cobalt, phosphorus, silicon, sulphur, tin and zinc are discussed thoroughly, while those of chromium, vanadium and titanium are considered when occurring in bronzes. A unique and valuable chapter concerns the analysis and control of plating solutions for deposition of brass, zinc, copper, silver, gold and nickel. It is an eminently useful and practical treatise, full of personal experiences and advice from the quite competent authors.

* * *

PRINCIPLES OF QUANTITATIVE ANALYSIS. By *Walter C. Blasdale.* Second Ed. Duodecimo (12 x 18 cm.), 402 pages, 70 cuts. Price, $2.50 net. New York: D. Van Nostrand Company.

This is not the usual laboratory handbook, nor is it a mere copy of Ostwald's "Grundlagen der analytischen Chemie." It is an adaptation of the latter to the laboratory training of a professional analytical chemist. It is about one-quarter directions what to do and three-quarters explanation of the why and wherefore, as derived from the principles of physical chemistry. A limited number of analyses are described, usually rather briefly, and chosen rather for their suitability to illustrate principles than for their commercial importance. The book and its method are stamped strongly with the personality (and the personal views) of the author, and unquestionably his students, working under and with him while using the book, will get fine insight into quantitative analysis. Any other wide-awake instructor, using the book and supplementing it by copious drafts upon his own personal energy, will also achieve similar results.

* * *

THEORY AND CALCULATION OF ELECTRIC CIRCUITS. By *Charles Proteus Steinmetz.* 362 pages, with illustrations. Price, $3.00. New York: McGraw-Hill Book Co., Inc.

This with its companion volume, "Theory and Calculations of Electrical Apparatus," may be considered as continuations, revisions or enlargements of his well-known book published about 20 years ago on "Theory and Calculation of Alternating Current Phenomena." To include the most necessary structural elements of our knowledge of electrical engineering the whole subject matter of the older volume is now issued in greatly enlarged form in the two present volumes and a third on "Alternating Current Phenomena," which together form a set of books which it will be well for all engineers of the advanced class to familiarize themselves with. Much of the present volume, being written in an easily understood style, is also of interest and of great value to those who have only an elementary knowledge of the science and application of electricity.

The author's masterly knowledge of the subject gives one confidence in his statement of facts, many of which are highly interesting; and his past and well-known success in the application of this knowledge to practice gives one confidence in his interesting opinions. One therefore feels safe to accept his unorthodox and somewhat novel classification and treatment of the subject. When the subject demands it the mathematical treatment is given, but involved mathematics is the exception rather than the rule.

From the standpoint of the electrochemist, of the 18 chapters parts of the first two on conducton are the most

interesting. His classification of conductors is based on the nature and properties of the conduction, and on this basis he classifies conductors under metallic, electrolytic, pyroelectric and electronic, thereby including such conduction as in the arc, in vacuum, discharges in gases, carbon, metallic silicon, boron, metallic oxides, magnetite, Nernst filaments, sulphides, silicates (glass), salts, etc. His own exhaustive researches with some of these conductors, like magnetite, tend to make his statements authoritative. By comparing the curves showing the relations between the volts and amperes he is enabled to make a better classification than when based on resistance alone.

The other sections are on magnetism, wave forms of currents, the instability of circuits, reactance, constant potential, constant current transformating, constant potential series operation, load balance of polyphase systems, circuits with distributed leakage, and oscillating currents, many of which subjects are often of interest also to the electrochemical engineer who has to deal with large quantities of electric power.

The high standing of the author as both an able scientist and a practical engineer, and the general recognition of his abilities, gives this book a stamp of authority; and his originality, logical reasoning, and independence of thought free from the bias of orthodoxy add interest to his books.

* * *

THEORY AND CALCULATIONS OF ELECTRICAL APPARATUS. By *Charles Proteus Steinmetz.* 480 pages, with illustrations. Price, $4.00. New York: McGraw-Hill Book Co., Inc.

The relation of this volume to its companion on "Theory and Calculation of Electric Circuits" and to the author's former "Theory and Calculations of Alternating Current Phenomena" are explained in the review of the former, above, and need not be repeated here.

In the present volume the author discusses the most important characteristics of electrical apparatus including not only those in use but also many that may attain industrial importance with changes in industrial conditions. As an illustration he cites the time when small cheaply developed water powers will be united into one system, controlled from the central receiving station, in which case an entirely different type of generating station will have to be developed.

By "electrical apparatus" the author limits himself almost entirely to alternating-current motors though some space is devoted also to a.c. generators and to allied apparatus like rotary converters, frequency changers, rotary rectifiers, etc. With the exception of a short chapter on unipolar machines, and short references to several old types of series arc light machines, direct-current generators and motors are not included, and those that are briefly referred to are treated as alternating-current generators with rotary rectifiers. Nor is the ordinary static transformer included, except briefly as a special case of the rotary transformer. It would have been more explicit therefore to have limited the title to alternating-current rotary machines.

The treatment of the subject is directed to those who are already familiar with such machines and their characteristics and therefore supplements the more usual descriptive treatises. While the treatment in some cases is mathematical in character, by far the greater part of the book is descriptive and discursive text freely illustrated with many diagrammatic drawings and curves. While intended for the more advanced student and designer, there are many parts of the text which are instructive and interesting reading for those of lesser attainments also.

The recognized ability of the author and his long experience in the application of the higher scientific studies to the requirements of industrial practice, give the book an authoritative character.

To the electrochemist who is concerned with alternating-current machnery for power purposes the points of interest are the discussions of the characteristics, properties and behavior of such machinery, which will aid him in a better choice for specific conditions, as for instance when many small water powers are to be combined into one centrally controlled plant.

Current Market Reports

The Iron and Steel Market

The railroads had 15 days of extremely favorable weather, Feb. 6 to 20, inclusive, this being followed by weather only moderately favorable. As great progress as could possibly be expected has been made in clearing congestion on the roads, and a large quantity of loaded freight that was blocking yards and sidings has been moved forward to destination. Naturally the railroads addressed themselves to this task first, and not much has thus far occurred by way of returning empties, so that car supplies at blast furnaces and mills have increased very slightly, and shipments have been in corresponding proportion. As the major portion of the congestion has now been cleared, expectations are entertained that there will be a continued and important improvement in the supply of empties, with increasing shipments all along the line.

In 1917 such restriction in steel output as occurred was due to lack of pig iron, the restriction in pig iron being due to insufficient movement of coke and coking coal. While at times steel mill operations were interfered with by one influence or another, they were able to make up losses and produce as much steel as there was pig iron to make. In December the shortage of cars at steel mills became such that the mills were not able to ship as much as they were producing, and finished steel began to accumulate in considerable tonnage. In January this condition was accentuated, and stocks became such that production had to be curtailed to the rate at which steel could be shipped. From that time to date the governing restrictive influence has been the ability of the railroads to move steel. With the Garfield holidays, which closed steel mills and not blast furnaces, pig iron began to accumulate, and January as a whole showed a smaller proportion than normal of steel ingot production to pig iron production. Steel ingots were produced in January at the rate of about 28,600,000 tons per annum, pig iron production being at the rate of about 28,750,000 tons, whereas in 1917 the outputs had been approximately 42,200,000 tons of ingots and 38,600,000 tons of pig iron.

With the loosening up of traffic conditions in February a great deal of coke that was stalled en route was moved forward to blast furnaces, and even though shipments of coke did not increase materially many furnaces received a great deal more coke than was currently needed. Blast furnace operations underwent a sharp increase, whereas there was little increase in production of finished steel, and the result was a further accumulation of pig iron, also some accumulation of steel in intermediate forms, which may have reached considerable proportions.

Shipments of finished steel products in January averaged about 55 per cent of the mill capacity, which is fully 35,000,000 gross tons a year of finished rolled steel, nearly if not quite 3,000,000 tons a month, and February shipments have not been at much heavier rate, probably exceeding 60 per cent only slightly.

At the beginning of March, traditionally one of the two months of the year in which record outputs are made, the other, of course, being October, the iron and steel industry finds itself with improving traffic conditions, but still with no situation that can promise a record production. Physical conditions at the mills are, however, such that shipments can be increased as rapidly as the railroads furnish additional transportation, no matter how rapid that increase may be. There are large stocks of finished steel at mill awaiting shipment, and there is accumulated material all along the line, in the form of billets, ingots and pig iron.

The effect upon the market of any large increase in steel shipments is problematical. There is no assurance that ordinary commercial users of steel, not connected with the war, will be able to use steel in the greatly increased quantities that would be available if the mills were able to operate and ship at capacity. At an outside estimate the steel shipments since the first of the year have represented 60 per cent of the capacity, about two-thirds of this being war steel of all descriptions, including steel for the Government and for its Allies and steel for those who have contracts with these governments, not more than one-third being

ordinary commercial steel, entirely dissociated from the war. There are very few cases, indeed, in which the shipments of war steel have not been adequate. As a rule the steel mills have been able to supply war steel as rapidly as it could possibly be used. In many cases the shipments are not up to the original schedules compiled, but the utilization of this steel in shipyards, shell factories, etc., has likewise been behind schedule. In the circumstances it seems improbable that under the most favorable conditions there will be occasion to speed up the shipment of war steel by more than a small proportion, say from the recent proportion of 40 per cent of capacity to 50 per cent or possibly 55 per cent. At 100 per cent operation of the steel mills the supply of commercial steel would then be 45 or 50 per cent, against not over 20 per cent in the past two months. It is quite improbable that any such consumption of commercial steel could occur. Of course it is likewise improbable that the steel mills will be able to operate at 100 per cent in the near future, but it is interesting to put the problem in this way.

The comparison is particularly to the point in view of the fact that Washington is making a fresh effort to develop a system for the curtailment of unessential consumption of steel. Washington has addressed itself to this matter a number of times in the past, but after thinking of "pleasure automobiles" (which the automobile producers much prefer to call "passenger automobiles") has been unable to proceed farther. In the steel trade efforts to curtail artificially the unessential consumption of steel are regarded as unnecessary, for as a matter of fact many steel makers are concerned lest demand shall fall short of supply in the next few months. Undoubtedly steel is scarce, but the degree of scarcity is a slight one by comparison with the degree to which shipments of commercial or "unessential" steel have been reduced.

When on Dec. 29 it was announced by authority of the President that the set prices for iron and steel would be continued for revision by March 31, it was commonly thought that the Pomerene iron and steel price fixing bill would pass Congress, quite possibly by the end of January. The latest information is that no such bill will be pressed for the time being, if ever. Government price revision, therefore, if it comes at all, will be under the same principles as hitherto. The market shows distinct possibilities of declining under the set prices, as to some commodities at least, and it is quite possible that Washington may be disposed to let Nature take her course.

Chemical Market

Coal Tar Products.—There was not a great deal of activity in this situation since the last writing, although trading in general was of improved tone. The delays entailed by chaotic shipping conditions continue to be a disturbing factor. Plants in some localities are also greatly hampered by the scarcity of coal. Several of the important items are scarce and prices are higher, which to an extent is due to the added requirements of the Government in the manufacture of necessities required in the prosecution of the war.

Benzol.—Slightly more business was closed on contract over the next few months, but there continues to be some hesitancy on the part of consumers to close over the entire year because of the uncertain price position.

Phenol.—There continues to be but small quantities offered, with prices slightly higher. The Government has contracted for the entire output of some producers.

Toluol.—There is practically none of this material available on the open market. From time to time a few drums are available, but the Government is releasing but little and only in case a real necessity is apparent.

Naphthalene has been more active of late than for some time heretofore. The demand has materially increased, but offerings are light, with prices higher.

Aniline Oil has been quiet, but prices are fairly firm, due to the scarcity of acids.

Beta Naphthol.—There is a fair volume of business passing in technical grade, but the other grades are not in heavy demand; prices are unchanged.

Benzaldehyde.—The toluol situation tends to restrict production and higher prices are expected, with only a few producers offering.

Para Nitraniline.—A fairly active business is passing, but the production is heavy and prices are unchanged.

Benzoate of Soda.—There has been a decrease in the consuming demand, with prices slightly lower.

Saccharine continues weak, with offerings heavy, but it is slightly firmer than a few weeks ago.

Para Amido Phenol is slightly firmer, due to an increased demand, but it is possible to do a fairly low figure on material quantities.

H. Acid has not been particularly active of late, but the production is not heavy and prices are well maintained.

Heavy Chemicals.—Trading in products under this classification during the past two weeks has been rather restricted except for special products in light supply and difficult to obtain. The export trade has been further hampered by the presidential proclamation placing all products on the embargo list and requiring licenses for foreign shipments. In addition all imports are now subject to Governmental supervision.

Caustic Soda.—Further declines have occurred in this product and in certain positions caustic has sold under the 5c. point. There has been practically no demand from consumers, the small amount of trading noted being for the account of dealers. January shipments from works were reported to have been small, notwithstanding the fact that cars have been loaded heavy; in some cases it is reported that cars have been loaded in excess of 80,000 lb. Consequently January bills of lading have commanded a premium since the first of the month. This has been the only position that has sold at a high figure. February-June has been available as low as 4.75c. A new production of some 500 tons monthly of ash and caustic is announced by a new company in Texas.

Soda Ash.—The market, in contrast to caustic, has held well and trading has been somewhat more active. Barrels have generally commanded substantial premiums, as seemingly export licenses are being granted. Dense ash is offered more liberally, but supplies are not abundant by any means. Generally ash at out-of-town points has been available on more favorable terms than at New York.

Bichromate of Soda.—This product has been more active than any of the heavy chemical items since we last reported. A pronounced scarcity of prompt material and a quiet but insistent demand has forced values skyward. However, the product is classified as one of a highly speculative character and the trade is rather inclined to remain away from it unless there is a genuine demand. Sales occurred at 25c. and 25½c. At the moment of writing the situation is a trifle easier.

Calcium Carbide.—The production is still much below the demand and sales are occurring at unthought-of prices. The demand from South America is still persistent, and sales of various sizes have been recorded at prices ranging from 12½c. to 15c., crated in drums. Some uncrated material has been sold at 12c. The Canadian producers have been quoting 8c. f.o.b., but no actual material has been available at the figure.

Zinc Oxide.—There is also a greater demand for this product than the producers can satisfy and considerable speculation is noted. The XX Horsehead brand has sold at prices ranging from 13c. to 15c. and even at these figures there is not a great deal of material available.

Sulphuric Acid.—The continued scarcity of tank cars has retarded the movement to a noticeable degree, and as a consequence acid has backed up upon the producers, with the result that the plants probably have more material on hand than they have had for many months. Of course the bulk of this is held for the account of the Government, but there have been numerous offers of 66-deg. brimstone acid in tanks at prices ranging from $40 to $45, f.o.b. works, according to amount and shipment. Considerable acid for export has sold at $90, f.a.s. New York, drums included. Sixty-degree acid has been offered in the South at $20 per ton, sellers' tanks, sellers' works, sellers' option.

Copper Sulphate.—Resale lots have been eliminated to a certain degree and this, coupled with a restricted production, has tended to increased firmness. Nichols brand has been offered rather sparingly and sellers have generally

held to 9½, less 1 per cent. Outside brands have been offered from 9c. to 9¼c.

Formaldehyde.—The difficulty in securing wood alcohol as a result of the Government assuming control of the industry has created a firmer tone and there is much bullish talk. Sales have occurred at prices ranging from 19¾c. up to 21c.

Glycerin.—After a prolonged period of inactivity there has been business passing in dynamite at prices ranging from 63½c. to 64½c. A number of cars of soap lye have changed hands at 46c. and 46½c., basis 80 per cent loose at New York. Offers in the West have been reported at lower figures, but owing to shipping difficulties have not found buyers.

Sodium Sulphide.—Lack of shipping facilities has retarded the movement and some spot lots have been available at lower prices. Shipments from works, however, have held well and the market is approximately 4c., f.o.b., for the 60/62 fused material.

Nitrite of Soda.—Spot lots have become rather scarce and sellers are now invariably holding for 35c. as a minimum trading level. The production has not been on a very elaborate scale of late and stocks are not abundant at any point.

Nitrate of Soda.—So far on account of the Government purchase of 100,000 tons of nitrate for direct distribution to the farmers two cargoes have arrived at southern points —one at Charleston and one at Savannah, totaling in all 13,000 tons. It is reported that the demand for this material has been much in excess of the amount available and the farmers have been eager purchasers at $3.75 per 100 lb., f.o.b. cars, cash in advance. This situation has naturally tended to depress the outside market, and there has been very little nitrate moving. Importers have been quoting $4.50 for prompt and future shipments at all ports, but resales have been reported at $4.30 at various points.

Acetic Anhydride.—The production is being taken over by the Government for the purpose of impregnating airplane wings, with the result that there is very little material available on the open market. Production is confined to comparatively few sources as heretofore.

Carbonate of Potash.—Offers are seemingly confined to the Japanese material and sellers ask from 95c. to $1.05.

Cellulose Acetate.—Production at the moment is confined to possibly four sources, and these makers are turning their entire product over to the airplane service of the army on the basis of $4.50 for an 8-oz. bottle.

Prussiates.—Considerable activity has been noted in yellow prussiate of potash and some 10 tons changed hands at prices ranging from $1.22½ to $1.25. At the moment sellers hold to $1.25 to $1.27½. Prussiate of soda has been firm at prices ranging from 37½ to 38½.

Non-Ferrous Metal Market

Monday, Feb. 25.—The interesting features during the past two weeks were the advance in lead and the continued scarcity of tin. There is nothing new in copper and zinc.

Copper—The Boston News Bureau states that the total production of fifteen large companies was less in January, 1918, than in January, 1917. This decrease is expected to continue for a short time, but during the latter part of the year substantial gains should be made. Copper prices remain the same, as fixed by the Government.

Tin—There is hardly any spot market for tin, as none is for sale, but futures are being purchased to a considerable extent, with April Straits commanding 74½c., May 72 to 73c. and June 72 to 72½c. The situation as to shipments is no better, but American authorities are making every effort to have stocks released in London.

Lead—The trust price of lead was advanced to 7.00c. on Feb. 11. Independents are asking 7⅛c. The market is quiet.

Spelter—There is nothing new. Prime Western is very dull at 7¾c. St. Louis and 7⅞c. New York.

Tungsten—Sales of wolframite have been made in considerable quantity at $20.00 for future shipment of off grade material up to $24.00 for high grade spot.

Manganese Ore—There is a good demand and a premium has been paid for foreign ore. The nominal quotation is $1.20 per unit, basis 48 per cent.

Chrome—High prices have been asked for high grade chrome ore, with the nominal quotation at 1.50 for 45 per cent material at the Pacific Coast.

Other Metals

Aluminium, lb.	.36–.38
Bismuth, lb.	2.50–2.75
Cadmium, lb.	1.50
Nickel, electrolytic, lb.	.55
Silver, oz.	.85⅞
Platinum, oz.	105.00
Palladium, oz.	135.00–137.00
Cobalt, lb.	3.25–3.50
Magnesium, lb.	2.00
Quicksilver, Cal.	120.00
Quicksilver, Mexican	115.00

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, FEB. 21, 1918

Acetic anhydride	lb.	1.35 —	1.50
Acetone, drums	lb.	Nominal	
Acid, acetic, 28 per cent	lb.	.05½—	06
Acetic, 56 per cent	lb.	.11¼—	12
Acetic, glacial, 99½ per cent, carboys	lb.	.35 —	36
Boric, crystals	lb.	.13¼—	14¼
Citric, crystals	lb.	.75 —	78
Hydrochloric, C. P	lb.	.08 —	09
Hydrochloric, 20 deg	lb.	.02½—	03
Hydrochloric, conc., 22 deg	lb.	.03 —	03½
Hydrofluoric, 30 per cent, in barrels	lb.	.06 —	06¼
Lactic, 44 per cent	lb.	.15 —	15½
Lactic, 22 per cent	lb.	.05¼—	06¼
Nitric, 36 deg.	lb.	Nominal	
Nitric, 42 deg.	lb.	.09½—	09½
Oxalic, crystals	lb.	.45½—	46½
Phosphoric, 47-50 per cent crude	lb.	.07½—	08
Phosphoric, refl. 50 per cent	lb.	.26 —	
Picric	lb.	Nominal	
Pyrogallic, resublimed	lb.	3.15 —	3.25
Sulphuric, 60 deg.	ton	35.00 —	35.00
Sulphuric, 66 deg.	ton	40.00 —	45.00
Sulphuric, oleum (Fuming), tank cars	ton	75.00 —	80.00
Tannic, U. S. P., bulk	lb.	1.30 —	1.35
Tartaric, crystals	lb.	.75 —	.78
Tungstic, per lb. of W	lb.	1.80 —	1.90
Alcohol, sugar cane, 188 proof	gal.	4.90 —	
Alcohol, wood, 95 per cent	gal.	1.35 —	1.38
Alcohol, denatured, 180 proof	gal.	.70 —	.72
Alum, ammonia lump	lb.	.04 —	.04¼
Alum, chrome ammonia	lb.	.18½—	.19
Alum, chrome potassium	lb.	.20½—	.22
Alum, chrome sodium	lb.	.12½—	13
Alum, potash lump	lb.	.09 —	09½
Aluminium sulphate, technical	lb.	.01¾—	02¼
Aluminium sulphate, iron free	lb.	.02¾—	03¼
Ammonia aqua, 26 deg. carboys	lb.	.20 —	.21
Ammonia, anhydrous	lb.	.40 —	.43
Ammonium carbonate	lb.	.11 —	.12
Ammonium nitrate	lb.	(Fixed price)	.14
Ammonium, sulphate domestic	lb.	.07¼—	.07½
Amyl acetate	gal.	5.00 —	5.25
Arsenic, white	lb.	.16¼—	.16½
Arsenic, red	lb.	.65 —	.70
Barium carbonate, 99 per cent	ton	80.00 —	90.00
Barium carbonate, 97-98 per cent	ton	65.00 —	67.00
Barium chloride	ton	65.00 —	85.00
Barium sulphate (Blanc Fixe, powder)	lb.	.03¾—	.04
Barium nitrate	lb.	.08½—	.08¾
Barium peroxide, basis 70 per cent	lb.	.30 —	.32
Bleaching powder, 35 per cent chlorine	lb.	.02¼—	.02½
Borax, crystals, sacks	lb.	.07¼—	.08¼
Brimstone, crude	ton	Nominal	
Bromine, technical	lb.	.75 —	
Calcium, acetate, crude	lb.	Nominal	
Calcium, carbide	lb.	.14¼—	.14½
Calcium chloride, 70-75 per cent, fused, lump	ton	21.00 —	22.00
Calcium peroxide	lb.	1.60 —	1.70
Calcium phosphate	lb.	.34 —	.35
Calcium sulphate 98-99 per cent	lb.	.09 —	.09½
Carbon bisulphide	lb.	.07½—	.08
Carbon tetrachloride, drums	lb.	.15½—	.16
Carbonyl chloride (phosgene)			
Caustic potash, 88-92 per cent	lb.	.84 —	.85
Caustic soda, 76 per cent	lb.	.05 —	.05¼
Chlorine, liquid	lb.	.15 —	.18
Cobalt oxide	lb.	1.60 —	1.65
Copperas	lb.	.01¼—	.01½
Copper carbonate	lb.	.45 —	
Copper cyanide	lb.	.75 —	.78
Copper sulphate, 99 per cent, large crystals	lb.	.09 —	09½
Cream of tartar, crystals	lb.	.59 —	.61
Epsom salt, bags	lb.	.03 —	.03½
Formaldehyde, 40 per cent	lb.	.19½—	.20
Glauber's salt	100 lb.	1.00 —	1.10
Glycerine, bulk, C. P	lb.	.63½—	.64½
Iodine, resublimed	lb.	4.25 —	4.35
Iron oxide	lb.	.13 —	.15
Lead, acetate, white crystals	lb.	.15 —	.18
Lead arsenate (Paste)	lb.	.15 —	.18
Lead nitrate	lb.	.15 —	.16
Litharge, American	lb.	.09½—	.11½
Lithium carbonate	lb.	1.50 —	2.00
Manganese dioxide, U. S. P	lb.	.70 —	.75
Magnesium carbonate, technical	lb.	.10½—	.11
Nickel salt, single	lb.	.14 —	.15
Nickel salt, double	lb.	.12 —	.14
Phosgene, see Carbonyl chloride			
Phosphorus, red	lb.	1.35 —	1.40
Phosphorus, yellow	lb.	1.50 —	1.60
Potassium bichromate	lb.	.48 —	.50
Potassium bromide granular	lb.	1.35 —	1.50
Potassium carbonate calcined, 85-90 per cent	lb.	.95 —	1.05

Potassium chlorate, crystals	lb.	.41	—	.42
Potassium cyanide, 98-99 per cent.	lb.	2.50	—	2.75
Potassium iodide	lb.	3.75	—	3.80
Potassium muriate 80-85 p. c. basis of 80 p. c	ton	340.00	—	350.00
Potassium nitrate	lb.	.27	—	.31
Potassium permanganate (U. S. P.)	lb.	4.00	—	4.10
Potassium prussiate, red	lb.	2.90	—	3.00
Potassium prussiate, yellow	lb.	1.28	—	1.30
Potassium sulphate, 90-95 p.c. basis 90 p.c.	ton	Nominal		
Rochelle salts	lb.	.39	—	.39½
Salammoniac, granular	lb.	.15½	—	.17
Salammoniac, white gran.	lb.	.15	—	.16
Sal soda	100 lb.	1.25	—	1.30
Salt cake	ton	25.00	—	26.00
Silver cyanide, based on market price of silver	oz.			
Silver nitrate	oz.	.57½	—	.58
Soda ash, 58 per cent, light, flat	100 lb.	2.90	—	3.05
Soda ash, 58 per cent, dense, flat	100 lb.	3.60	—	4.00
Sodium acetate	lb.	.16½	—	.17
Sodium bicarbonate, domestic	lb.	.02⅝	—	.03
Sodium bicarbonate, English	lb.			
Sodium bichromate	lb.	.23¾	—	.24
Sodium bisulphite, powd.	lb.	.08	—	.10
Sodium chlorate	lb.	.24	—	.25
Sodium cyanide	lb.	.40	—	.41
Sodium fluoride, commercial	lb.	.17	—	.18
Sodium hyposulphite	lb.	.02½	—	
Sodium molybdate, per lb. of Mo	lb.	2.50	—	
Sodium nitrate, 95%	100 lb.	4.50	—	4.60
Sodium nitrite	lb.	.35	—	.36
Sodium peroxide	lb.	.45	—	.50
Sodium phosphate	lb.	.04	—	.04½
Sodium prussiate, yellow	lb.	.37	—	.40
Sodium silicate, liquid (60 deg.)	lb.	.03½	—	.04½
Sodium sulphide, 30 per cent., crystals	lb.	.02¾	—	.03
Sodium sulphide, 60 per cent., fused	lb.	.05	—	.05½
Sodium sulphite	lb.	.05	—	.06
Strontium nitrate	lb.	.25	—	.35
Sulphur chloride, drums	lb.	.06	—	.06½
Sulphur dioxide, liquid, in cylinders	lb.	.15	—	.40
Sulphur, flowers, sublimed	100 lb.	3.85	—	4.40
Sulphur, roll	100 lb.	3.70	—	3.85
Sulphur, crude	ton	35.00	—	37.50
Tin bichloride, 50 deg.	lb.	Nominal		
Tin oxide	lb.	.75	—	.90
Zinc carbonate	lb.	.25	—	.30
Zinc chloride	lb.	10¼	—	.11
Zinc cyanide	lb.	Nominal		
Zinc dust, 350 mesh	lb.	.14	—	.16
Zinc oxide, American process XX	lb.	.13	—	.14
Zinc sulphate	lb.	.06	—	.07

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.35	—	.40
Benzol, 90 per cent	gal.		—	
Toluol, pure water white	gal.	Nominal		
Xylol, pure, water white	gal.	.35	—	.50
Solvent naphtha, water white	gal.	.17	—	.22
Solvent naphtha, crude, heavy	gal.	.13	—	.16
Creosote oil, 25 per cent.	gal.	.33	—	.35
Dip oil, 20 per cent	gal.	.29	—	.30
Pitch, various grades	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05	—	1.10
Carbolic acid, crude, 50 per cent	lb.	.60	—	.65
Carbolic acid, crude, 25 per cent	lb.	.35	—	.38
Cresol, U. S. P	lb.	.18	—	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00	—	1.25
Alpha naphthol, distilled	lb.	1.60	—	2.00
Alpha naphthylamine	lb.	.58	—	.60
Aniline oil, drums extra	lb.	.27	—	.28
Aniline salts	lb.	.32	—	.34
Anthracene, 80 per cent	lb.	.50	—	.65
Benzaldehyde (f.f.c.)	lb.	4.50	—	5.50
Benzidine, base	lb.	1.75	—	1.85
Benzidine, sulphate	lb.	1.40	—	1.50
Benzoic acid U. S. P.	lb.	5.50	—	5.75
Benzoate of Soda, U. S. P.	lb.	4.50	—	4.75
Benzyl chloride	lb.	2.25	—	2.50
Beta naphthol benzoate	lb.	10.00	—	12.00
Beta naphthol, sublimed	lb.	.85	—	.90
Beta naphthylamine, sublimed	lb.	2.65	—	
Dichlor benzol	lb.	.12	—	.18
Diethylaniline	lb.	4.00	—	5.00
Dinitro benzol	lb.	.35	—	.40
Dinitrochlorbenzol	lb.	.40	—	.42
Dinitronaphthaline	lb.	.55	—	.60
Dinitrotoluol	lb.	.55	—	.60
Dinitrophenol	lb.	.50	—	.55
Dimethylaniline	lb.	.63	—	.65
Diphenylamine	lb.	1.00	—	1.10
H-acid	lb.	2.25	—	2.50
Metaphenylenediamine	lb.	1.85	—	2.00
Monochlorbenzol	lb.	.19	—	.22
Naphthalene, flake	lb.	.10½	—	.11
Naphthalene, balls	lb.	.12	—	.14
Naphthionic acid, crude	lb.	1.40	—	1.50
Naphthylamin-di-sulphonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.45	—	.50
Nitro toluol	lb.	.50	—	.55
Ortho-amidophenol	lb.		—	
Ortho-dichlor-benzol	lb.	.15	—	.18
Ortho-toluidine	lb.	1.00	—	1.20
Ortho-nitro-toluol	lb.	.75	—	1.00
Para-amidophenol, base	lb.	3.50	—	4.00
Para-amido-phenol, H. Ch.	lb.	4.00	—	5.00
Para-dichlor-benzol	lb.	.12	—	.15
Paranitraniline	lb.	1.05	—	1.15
Para-nitro-toluol	lb.	1.50	—	1.60
Paraphenylenediamine	lb.	3.00	—	3.50
Para toluidine	lb.	2.25	—	2.50
Phthalic acid anhydride	lb.	4.50	—	5.00
Phenol, U. S. P.	lb.	.53½	—	.55
Resorcin, technical	lb.	6.00	—	7.00
Resorcin, pure	lb.	9.00	—	10.00
Salicylic acid	lb.	1.00	—	1.10
Salol	lb.	1.85	—	2.00
Sulphanilic acid, crude	lb.	.32	—	.35
Tolidin	lb.	2.50	—	
Toluidine-mixture	lb.	.75	—	.85

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4.00	—	
Corning, Ohio	bbl.	2.85	—	
Somerset, Ky.	bbl.	2.60	—	
Wooster, Ohio	bbl.	2.38	—	
Indiana	bbl.	2.08	—	
Illinois	bbl.	2.22	—	
Oklahoma and Kansas	bbl.	2.00	—	
Caddo, La., light	bbl.	2.00	—	
Corsicana, Tex., light	bbl.	2.00	—	
California	bbl.	.98	—	1.32
Gulf Coast	bbl.	1.00	—	
Fuel Oil				
New York	gal.	.11	—	
Pittsburgh	gal.	.07½	—	.10
Oklahoma-Kans.	bbl.	1.50	—	2.35
Texas	bbl.	1.50	—	1.90
Los Angeles	bbl.	1.52	—	
San Francisco	bbl.	1.45	—	
Gasoline (Wholesale)				
New York	gal.	.24	—	
Boston	gal.	.25	—	
Pittsburgh	gal.	.26	—	
Chicago	gal.	.21	—	
Oklahoma	gal.	.25	—	
San Francisco	gal.	.20	—	

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.19	—	.20
Cylinder, light	gal.	.34	—	.35
Cylinder, dark	gal.	.33	—	.34
Paraffine, high viscosity	gal.	.36	—	.37
Paraffine, 903 sp. gr	gal.	.29	—	.30
Paraffine, .865 sp. gr	gal.	.21	—	.22

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f.o.b. Florida	gal.	.44	—	
Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.53	—	
Pine oil, destructively distilled	gal.	.49	—	.53
Pine-tar oil, sp. gr., 1.025-1.035	gal.	.35	—	
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.40	—	
Pine oil, light, sp. gr. 0.930, tank cars, f.o.b. works	gal.	.37	—	
Pine oil, heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.26	—	
Pine tar, thin, sp. gr. 1.060-1.080	gal.	.30	—	
Turpentine, crude, sp. gr. 0.980-1.000	gal.	.40	—	
Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990	gal.	.19	—	
Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08	gal.	.19	—	
Wood creosote, ref. f.o.b. Florida	gal.	.31	—	

Vegetable and Other Oils

China wood oil	lb.	.20½	—	.21
Cottonseed oil, crude	lb.	.17½	—	.18
Linseed oil, raw, cars	gal.	1.30	—	1.32
Peanut oil, crude	gal.	1.37	—	
Rosin oil, first run	gal.	.35	—	
Rosin oil, fourth run	gal.	.66	—	
Soya bean oil, Manchuria	lb.	.18¾	—	.19
Turpentine, spirits	gal.	.47½	—	

Miscellaneous Materials

Barytes, floated, white, foreign	ton	40.00	—	50.00
Barytes, floated, white, domestic	ton	30.00	—	36.00
Beeswax, white, pure	lb.	.56	—	.64
Casein	lb.	.22	—	.30
Chalk, light, precipitated, English	lb.		—	
Feldspar	ton	8.00	—	12.00
Fuller's earth, powdered	100 lb.	1.00	—	1.50
Ozokerite, crude, brown	lb.	.65	—	.75
Ozokerite, American, refined, white	lb.	.75	—	1.00
Red lead, dry, carloads	lb.	.10	—	.11¼
Rosin, 280 lb	bbl.	7.00	—	
Soapstone	ton	10.00	—	12.50
Talc, American, white	ton	15.00	—	22.00
White lead, dry	lb.	.09	—	.10

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	Nominal		
Chrome cement, Grecian	net ton	Nominal		
Clay brick, 1st quality fireclay	per 1000	50.00	—	55.00
Clay brick, second quality	per 1000	35.00	—	40.00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined	ton	35.00	—	36.00
Magnesite, Grecian, dead burned	net ton	85.00	—	90.00
Magnesia brick, Grecian, 9x4½x2½	net ton	135.00	—	140.00
Silica brick	per 1000	50.00	—	60.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f.o.b. Niagara Falls, N. Y.	ton	160.00	—	
Ferrocerium	lb.	18.00	—	
Ferrochromium, per lb. of Cr	lb.	.50	—	
Ferromanganese, domestic	ton	250.00	—	
Ferromanganese, English	ton	325.00	—	
Ferromolybdenum, per lb. of Mo	lb.	5.00	—	
Ferrosilicon, 75 per cent, f.o.b. N. Y.	ton		—	
Ferrosilicon, 50 per cent, carloads, del., Pittsburgh	ton	165.00	—	175.00
Ferrosilicon, 50 per cent, contract	ton	100.00	—	175.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	2.35	—	2.45
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.00	—	
Ferrovanadium, f.o.b. works	lb.	4.00	—	5.00

Ores and Semi-finished Products

Antimony ore, per unit		1.60	—	1.75
Chrome ore, 48 per cent minimum, f.o.b. Cal., per unit	ton	1.50	—	
Manganese ore, 48 per cent and over, per unit	ton	1.20	—	
Manganese ore, chemical	ton	80.00	—	100.00
Molybdenite, per lb. of MoS_2	lb.	2.15	—	
Tungsten, Scheelite, per unit of WO_3	ton		—	
Tungsten, Wolframite, per unit of WO_3	ton	24.00	—	
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	
Pyrites, foreign	unit	.17	—	.17½
Pyrites, domestic	unit	.28	—	.30

INDUSTRIAL

Financial, Construction and Manufacturers' News

New Companies

THE AMERICAN ALLOY & CHEMICAL CORPORATION, Los Angeles, Cal. Capital, $1,000,000. To manufacture chemicals and allied specialties. Incorporators: J. L. Boyle, G. A. Green, G. H. Beesemeyler, F. L. Riley, B. J. Quinn, and J. L. Stevens.

THE ANACONDA LEAD & ZINC COMPANY, Dover, Del. Capital, $100,000. To engage in a general mining and milling of lead and zinc. Incorporators: L. B. Phillips, and J. B. Bailey, Dover.

THE ATLAS DRAWN STEEL CORPORATION, Dunkirk, N. Y. Active capital, $275,000. To manufacture various drawn steel products. Incorporators: A. H. Hunter, A. F. Dohn, and H. E. Webster, Buffalo.

THE AURORA SILVER MINES CORPORATION, New York. Capital, $1,000,000. To engage in a general mining business. Incorporators: S. B. Howard, George V. Reilly, and A. W. Britton, 65 Cedar Street.

THE BANKERS LEAD & ZINC COMPANY, Oklohama City, Okla. Capital, $250,000. To mine for lead and zinc. Incorporators: G. A. Morris, W. A. McAtee, and H. E. Brouillard, Wapanucka, Okla.

THE BEST MINING COMPANY, Shawnee, Okla. Capital, $200,000. To mine for lead and zinc. Incorporators: S. H. Lester, M. J. McLaughlin, and H. B. Callahan.

THE BONE-DRY LIME CORPORATION, Jamestown, N. Y. Capital, $100,000. To manufacture commercial fertilizer, etc. Incorporators: C. Lamberton, Franklin, Pa.; J. C. Dick, Utica; and A. Davis, Jamestown, N. Y.

THE BUCKNER PROCESS COMPANY, Worcester, Mass. Capital, $20,000. To manufacture chemicals, petroleum products, and allied specialties. Harry L. Buckner, Wollaston, is the principal incorporator.

A. M. CASTEL & COMPANY, Dover, Del. Capital, $1,500,000. To manufacture tools and iron and steel products.

THE CHLORINE PRODUCTS COMPANY, New York. Capital, $100,000. To manufacture chemicals and kindred specialties. Incorporators: S. B. Howard, G. V. Reilly, and A. W. Britton, 65 Cedar Street.

THE CLAREMONT PAPER COMPANY, Bellows Falls, Vt. Capital, $1,500,000. To manufacture paper, etc. Incorporators: J. N. Harvey, Harold E. Whitney and H. C. Fenton, Brattleboro.

THE CLARK COUNTY OIL & GAS COMPANY, Montgomery, Ala. Capital, $100,000. To manufacture gas and produce and refine oil. Incorporators: J. C. McCarquadale, F. H. Grande, and C. T. McCarquadale.

THE CRESCENT COLOR & CHEMICAL WORKS, Plainfield, N. J. Capital, $25,000. To manufacture colors and chemicals, etc. Incorporators: A. and J. and Walter Alexander, all of New York.

THE CRESCENT LEAD & ZINC COMPANY, Miami, Okla. Capital, $250,000. To operate lead and zinc properties. Incorporators: J. A. Utterback, O. E. and W. A. Doty, Newkirk.

THE D-B-L PRODUCTS CORPORATION, New York. Capital, $150,000. To manufacture celluloid products. Incorporators: A. W. Burke, C. H. Louis, and I. L. Ernst, 151 West Eighty-sixth Street.

THE DIAMOND CHEMICAL COMPANY, Utica, N. Y. Nominal capital, $7,000. To manufacture chemicals. Incorporators: F. A. Hill and H. J. Willett, Utica.

THE ELLSWORTH MINING COMPANY, Miami, Okla. Capital, $150,000. To engage in a general lead and zinc mining business. Incoroprators: Lloyd Weber, J. Wise Brown, Tulsa, and A. B. Elisworth, Joplin, Mo.

THE FLORENCE PIPE FOUNDRY & MACHINE COMPANY, Philadelphia, Pa. Capital, $1,000,000. To operate a foundry and engage in the manufacture of special machinery. Incorporators: Charles R. Wood, Spencer P. Hazard, Edwin J. Lane, Philadelphia; Thomas L. Morton, Palmyra, N. J.

THE FORGE PRODUCTS CORPORATION, New York. Capital, $160,000. To manufacture high speed steel products. Incorporators: A. E. Moore, F. H. Butehorn, and A. F. McCabe.

THE FOUR STATES MINING COMPANY, Idabel, Okla. Capital, $50,000. To mine for lead and zinc. D. B. Strawn is the principal incorporator.

THE GALCONDA MINING COMPANY, Ardmore, Okla. Capital, $15,000. To mine for lead and zinc. Incorporators: John M. Imrie, E. E. Chivers, and O. C. Lasher.

THE GIVENS MINING COMPANY, Athens, Ga. Capital, $64,000. To mine for gold. Incorporators: E. L., A. J. Haughey, and Theodore Brough, Athens.

R. H. GREEFF & COMPANY, New York. Capital, $200,000. To manufacture chemicals and allied products. Incorporators: W. N. Barnum, F. E. Dixon, and R. H. Greeff, New York.

THE GREENFIELD LEAD & ZINC COMPANY, Greenfield, Okla. To mine for lead and zinc. Incorporators: J. E. Ross, J. C. Collier, and J. W. Baker, Greenfield.

THE HANCOCK FOUNDRY & MACHINE COMPANY, New Cumberland, W. Va. Capital, $25,000. To operate a local steel plant.

THE INTERNATIONAL IRON & STEEL COMPANY, Augusta, Me. Capital, $250,000. To manufacture iron and steel products. E. M. Leavitt, Augusta, is president and treasurer.

THE INYO CHEMICAL COMPANY, Reno, Nev. Capital, $1,000 000. To manufacture chemicals and chemical compounds. Incorporators: H. W. Carr, Saginaw, Mich.; J. N. Morris, and W. M. Gardner, Reno.

JENNINGS & COMPANY, Boston, Mass. Capital, $90 000. To manufacture dyestuffs, etc. Incorporators: F. W. Bourne, Waldo Farrar, and C. W. Jennings, Boston.

THE KNOX DRAWN STEEL COMPANY, Pittsburgh, Pa. Nominal capital, $5,000. To manufacture drawn steel products. J. G. Bassett is the principal incorporator.

LAWLESS BROTHERS PAPER MILLS, Rochester, N. Y. Capital, $150,000. To manufacture paper and paper products. Incorporators: M. D., M. J. and D. J. Lawless, Rochester.

H. S. LENT, INC., New York. Capital, $25,000. To manufacture cordage and twine from hemp fibre, etc. Incorporators: W. Coemen, F. E. Fehr, and R. S. Strahan, 44 West Ninth Street.

THE LIBERTY STEEL & FOUNDRIES COMPANY, New York. Capital, $1,500,000. To manufacture iron and steel products, etc.

THE LORANE MINING & ROYALTY COMPANY, Miami, Okla. Capital, $40,000. To mine for lead and zinc. Incorporators: Ray Thompson, C. C. Moses, J. T. Dewberry and J. T. Gephart.

THE LYON SOAP PRODUCTS COMPANY, New York. Capital, $25 000. To manufacture soaps and soap products. Incorporators: A. DeGobi J. E. McCullough, and L. S. Furman, 356 East Twelfth Street.

THE MANUFACTURERS PRODUCTS COMPANY, New York. Capital, $100,000. To manufacture chemicals, leather product, etc. Incorporators: H. C. Neuberger, H. Burlingham, and C. M. Chapman, 2 Rector Street.

THE MOGUL MINING COMPANY, Oklahoma City, Okla. Capital, $250,000. To mine for lead and zinc. Incorporators: F. E. Sheets, T. F. Tate, and W. L. Buck.

THE MONTANA CHROME MINING COMPANY, Philadelphia, Pa. Capital, $1,000,000. To engage in a general mining business. Incorporators: F. R. Hansell, Philadelphia; J. V. Pinm and S. C. Seymour, Camden, N. J.

THE MORE PRODUCTS COMPANY, Los Angeles, Cal. Capital, $10,000. To manufacture fertilizers from kelp, etc. Incorporators: Frank Martin, George Cunningham, Z. Jones, and E. W. Tunsgate, Los Angeles, and H. M. Henning, Santa Barbara.

THE NEW HAVEN IRON & STEEL COMPANY, New Haven Conn. Nominal capital, $9,000. To manufacture iron and steel products. Incorporators: William Alderman, Charles Merberg, M. A. and A. N. Alderman, New Haven.

THE NOEQUA CHEMICAL COMPANY, Philadelphia, Pa. Capital, $450,000. To engage in the manufacture of chemicals and allied products.

THE ORETON COMPANY, Wilmington, Del. Capital, $100,000. To manufacture iron and steel products.

THE ORGANIC PRODUCTS & COLOR COMPANY, Elizabeth, N. J. Capital, $50,000. To engage in the manufacture of dyestuffs and allied products. Incorporators: Hugo Helburn, Seymour M. Hermann, New York; and Charles B. Rasenberger, Brooklyn.

THE PARKER TIRE & RUBBER COMPANY, Dover, Del. Capital, $750,000. To manufacture automobile tires and other rubber goods. Incorporators: M. L. Horty and K. E. Longfield, Wilmington.

THE PEARSE ENGINEERING COMPANY, Ltd., Dover, Del. Capital, $100,000. To engage as chemical engineers. Incorporators: J. G. Gray, M. B. F. Hawkins, S. S. Adams, Jr., Wilmington.

THE POLLOCK-BURT PAPER COMPANY, Dallas, Tex. Capital, $10,000. To manufacture paper and paper products. Incorporators: Lawrence S. Pollock, S. Dreyfuss, and William J. Burt.

ASHMEAD F. PRINGLE, Inc., Charleston, S. C. Capital, $200,000. To engage in the manufacture of fertilizers. Incorporators: A. F., E. H. Pringle, and Frank E. Barron, Charleston.

THE QUENEIDA GRAPHITE CORPORATION, Birmingham, Ala. Capital, $3,000,000. To engage in the production of graphite. Incorporators: J. F. B. Baugh, Birmingham; J. D. Baker and J. P. Murray, Philadelphia, Pa.

RENAUD & COMPANY, Inc., New York. Capital, $25,000. To engage in a general mining business. Incorporators: G. Renaud J. S. Galland, and D. J. Dowling, 20 Stuyvesant Place, State Island.

THE SALICYLATE PRODUCTS MANUFACTURING COMPANY, Newark, N. J. Capital, $25,000. To manufacture chemicals and allied products. Incorporators: A. C. Ullman, Charles D. Wagler and William P. Murphy, all of Newark.

THE SEMINOLE CHEMICAL COMPANY, New York. Capital, $100,000. To manufacture chemicals. Incorporators: M. Suesskind and I. J. Joseph, 1421 Madison Avenue.

THE SEMINOLE VARNISH COMPANY, Tampa, Fla. Capital, $500,000. To manufacture varnishes, etc. Incorporators: Gustave Tuschell, 144 Lafayette Street, Tampa.

THE SMITHVILLE ORE CONCENTRATING COMPANY, Inc., New York. Capital, $70,000. To mine for ores of various kinds. Incorporators: K. L. Alexander, M. Anelli, and E. Powers, 15 Broad Street, New York.

LEOPOLD SONN & BROTHER, New York Capital, $30,000. To manufacture paper, paper boxes, and other paper specialties Incorporators: S. H. and F. and L. Sonn, 132 Mulberry Street.

THE STEEL SPECIALTY CORPORATION, Pawtucket, R. I. Capital, $100,000. To manufacture steel products. Incorporators: Fred A. Sweet, Walter A. Briggs and George E. Thurber.

THE TANTEX LEATHER CORPORATION, Newark, N. J. Capital, $100,000. To engage in the manufacture of leather, leather products, etc. Incorporators: Charles L. Mason, Harold Bouton and F. J. Israel, Newark.

THE UNION STEEL PRODUCTS COMPANY, New York. Capital, $100,000. To engage in the manufacture of steel products. Incorporators: R. Tally and I. and M. Gordon, 700 West One Hundred and Eightieth Street.

THE UNITED STATES AND BRAZIL EXPORT COMPANY, Inc., New York. Capital, $10,000. To deal in chemicals and dyestuffs Incorporators: James W. McGovern and Joseph Gambaro.

THE UNIVERSAL IRON PRODUCTS COMPANY, Wilmington, Del. Capital, $1,200,000. To manufacture steel rails, iron bars, culverts, etc Incorporators: M. Gehrman, William F. O'Keefe, and E. E. Wright Wilmington.

THE VALLEY MINING COMPANY, Miami, Okla. Capital, $150,000. To engage in a general mining business for the production of lead, zinc, etc. Incorporators: R. T. Price, J. A. Stokes and H. Russell

THE WESTERN MAGNESIA PRODUCTS CORPORATION, New York. Capital, $10,000. To manufacture magnesia products. Incorporators: V. W. Thorpe, O. J. Heig and I. V. Weisdrob, 71 Broadway.

THE D. L. WILKOFF STEEL COMPANY, Pittsburgh, Pa. Capital, $50,000. To manufacture steel products. H. T. Feinberg is the principal incorporator

THE WILMINGTON SUGAR REFINING COMPANY, Dover, Del. Capital, $15,000,000. To manufacture and refine sugar and molasses. Incorporators: Adolph and Earl Segal, and Thomas B. Hall, Philadelphia, Pa.

THE WOODBRIDGE CERAMIC CORPORATION, Woodbridge, N. J. Capital, $30,000. To manufacture fire brick, etc. Incorporators: N. Peter Jensen, P. P. Svhendorf and William H. Prall, Woodbridge.

Construction and Operation

Alabama

ASHLAND. — The Crystalline Flake Graphite Company is making rapid progress in the construction of its new mill for the concentration of graphite and it is anticipated that operations will be inaugurated about March 15.

Arizona

BISBEE.—The Dos Cabezos Gold Ridge Mining Company, with properties in Cochise County, is planning for the immediate construction of a new mill to have a capacity of 100 tons. The company has been doing extensive development work at its mines, and it is estimated that the ore reserve is sufficient to supply the proposed new mill for about ten years.

PEARCE.—The Middlemarch Mining Company, about seven miles west of Pearce, has completed the construction of a new flotation plant, and will inaugurate operations at an early date.

PRESCOTT.—Plans are being considered by the Consolidated Arizona Smelting Company for the immediate enlargement of its smelter, the plant, when completed, to have a capacity of 2,500,000 pounds of copper per month.

PRESCOTT.—The Locey Pabst Gold Mines Company has completed the installation of new electrical equipment at its properties, and is planning for the immediate construction of a new mill to have a capacity of 100 tons daily.

SAN XAVIER.—The Mineral Hill Consolidated Mining Company is planning for extensive development work at its properties in the San Xavier district, Pima County. The main shaft has been sunk to a depth of 500 feet, the ore that is being blocked out assaying 4 per cent copper. A new duplex electrical pump, capable of handling 250 gallons per minute is now being placed, the power to be supplied by a 75-horsepower semi-Diesel Y-type engine and 50-kw. generator.

Arkansas

CONWAY.—Fire, on February 10, originating in the lint room of the plant of the Conway Cotton Oil & Gin Company, caused a loss of approximately $20,000.

FORT SMITH.—The Fort Smith Smelter Company, which is now operating three blocks of its four-block smelter at South Fort Smith, is planning to place the fourth block of the plant in operation at an early date.

LITTLE ROCK.—The Southern Paint Manufacturing Company, manufacturer of a special roofing paint, is planning for the removal of its plant and offices from Camden to Little Rock. The company controls extensive lignite mines at Corcoran Spur, and through a special retorting process, produces a high grade carbon from the lignite, which carbon is used as a base for the company's roofing paint, iron paint and darker colored house paints.

California

FRESNO.—The California Products Company has awarded a contract for the construction of a new reinforced-concrete drier at its plant, which was recently destroyed by fire. The new drier is estimated to cost $60,000. The company is contemplating the construction of a new acid plant, concrete storage towers, and new elevator system. The Cahill-Vensano Company, San Francisco, is the contractor.

LOS ANGELES.—The Chemical Production Company is making rapid progress in the construction of a large new plant at Owens Lake, to be devoted to the manufacture of soda ash.

LOS ANGELES.—The Stauffer Chemical Company, manufacturer of chemicals and kindred products, is building a new plant on a site comprising about fifteen acres, recently acquired, to be devoted to the production of hydrochloric acid. The new works are estimated to cost about $100,000.

LOS ANGELES.—The Western Calcium Chloride Syndicate has completed the equipment of a large new plant for the manufacture of calcium chloride.

SAN DIEGO.—The Steele Packing Company is considering the lease of a large site on the tidelands at the foot of Jupiter street, to provide for the construction of a large fish packing and reduction plant. The entire works are estimated to cost about $70,000.

RANDSBURG.—The Yellow Aster Mining Company has commenced the operation of its old mill, which has been idle for some time, pending the completion of the new plant now in course of construction. Development work at the mine has uncovered ore buried by the great slide of 1914, and in the new plant, which will be double the capacity of the former, the coarse product will be eliminated by screening, and the fine ore, containing practically all the gold, will be fed directly into the stamps. Plans are under consideration by the company for the mining of its large bodies of low-grade ore by steam shovels or a cableway excavator, and is considering the installation of a set of ball-mills to replace the stamp mill.

SAN FRANCISCO.—Fire recently partially destroyed the plant of the Eagle Tanning Company, Vermont street and San Bruno avenue, with loss estimated at $50,000.

PORTOLA.—The Anaconda Copper Company is said to have completed arrangements for taking over the interest of the Plumas Copper Company in the Walker Mine, about 25 miles from Portola, for a consideration of $500,000. For the past few months the mine has been developed under the direction of the International Copper Company, and concentrate from the flotation plant has been shipped to the Tooele smelter. The flotation plant has a daily capacity of 160 tons.

WASHINGTON.—The Washington Asbestos Company is planning to inaugurate operations in its mill at an early date. The company has been developing its asbestos claims all through the winter.

AUBURN.—The Pacific Coast Mines Company has recently acquired title to the Dutch, Sweeney, and App mines, and is preparing plans for extensive development work. The company is considering the immediate construction of a large new mill to have a capacity of about 700 tons daily. Experiments have also been perfected for a special treatment for the sulphide ore.

YERINGTON.—The Kennedy Copper Company is planning extensive development work at its mines in the Buckskin Mountain, near Yerington, and is considering plans for the construction of a new flotation plant in the early spring.

Colorado

EUREKA.—Rapid progress is being made by the Sunnyside Mines Company in the construction of a new crusher plant and 500-ton flotation works at its mines.

PUEBLO.—The Colorado Fuel & Iron Company is planning to inaugurate operations at an early date in its new by-product coke ovens at the Minnequa works, now in course of construction. The plant consists of two batteries of sixty ovens each, designed for sixteen-hour coke, to have a capacity of approximately 70,000 tons of coal a month, with a coke production of 46,000 tons. The new plant, which will comprise the ovens, benzol works, coal washer, and other structures is being erected by the H. Koppers Company, Pittsburgh, Pa., and is estimated to cost about $4,000,000.

DENVER.—Plans have been perfected for the organization of the American Mineral Oil Company, which has acquired about 1400 acres of shale fields and is planning for the construction of a large plant for the production of oil. H. M. Roeschlaub, Denver, heads the company.

Connecticut

STAMFORD.—The American Synthetic Color Company has filed plans for the construction of its proposed new two-story brick and concrete addition, about 30x130 feet, on Sunnyside avenue. Contract has been awarded to Harold A. Parsons, Bank street, Stamford, at a price of $12,000.

Delaware

WILMINGTON.—The E. I. du Pont de-Nemours Company has awarded a contract for the construction of a new plant for the manufacture of powder and high explosives at Sattes, W. Va., to cost about $10,000,000. The Thompson-Starrett Company, 49 Wall street, New York, is the contractor. It is said that the company has made arrangements with the War Department for the erection of two plants at Charleston, W. Va., and Nashville, Tenn., respectively, to have a capacity of about 1,000,000 pounds of smokeless powder daily, combined.

WILMINGTON.—The Ball Grain Powder Company, recently incorporated, will build a new one-story shell-loading plant at Miller road and Thirty-second street. Pans for the structure have been prepared.

WILMINGTON.—Fire on February 16, at the local recovery plant of the du Pont Powder Company, seriously damaged one of the buildings.

WILMINGTON.—The plant of the Baldt Steel Company, which is engaged on work for the Government, was damaged to the extent of about $150,000 by fire, on February 16.

Georgia

ATLANTA.—Fire, on February 12, partially destroyed the plant of the Southern Chemical Products Company, following an explosion.

Idaho

WALLACE.—Rapid progress is being made by the Spokane Metals Recovery Company in the construction of a new 200-ton plant on Nine Mile Creek, about three miles from Wallace, and it is expected to inaugurate operations at an early date. The equipment includes a flotation system and tables, the water of the creek and its mineral content being conveyed to the plant by a 500-foot flume. C. L. Hewett is president and manager of the company.

Illinois

CHICAGO.—The American Tractor Company, South Michigan avenue, will build a new tractor plant at Peoria, to include two foundry buildings, assembling works, machine shop, main manufacturing building, power plant, and auxiliary structure. Plans for the work are being prepared. The entire plant is estimated to cost about $150,000.

CHICAGO.—The Twin Tube & Rubber Company, South Michigan avenue, has filed plans for the construction of a new one-story and basement works. Contract for the structure, which will be about 40x40 feet, has been awarded.

CHICAGO.—The Indian Refining Company has recently acquired property on Western avenue, between the right of way of the Atchison, Topeka & Santa Fe Railroad and the Illinois and Michigan Canal, for a consideration of about $20,000, as a site for the construction of a new compounding and distributing plant.

GALENA.—The Blewett Mining Company, recently incorporated with a capital of $100,000, is planning for extensive development work on its zinc ore properties about half a mile from Galena. Work has been started on a new shaft, and the company is considering plans for the immediate construction of a mill building.

Indiana

WHITING.—The Sinclair Oil Company is making favorable progress in the construction of its new local refinery. The company has made announcement that the laying of a pipe line from the mid-continent field to Whiting has been practically completed. This pipe line has been in course of construction for about two years, and is the second of its kind to cross the Mississippi River, the Standard Oil Company having laid the first one.

GREENCASTLE.—The Indiana Portland Cement Company is having plans prepared for a new cement works to cost about $1,000,000. The plant will include a main manufacturing building, cement mill, machine shop, and auxiliary structures. Adam Beck is president.

INDIANA HARBOR.—Plans have been filed and contract awarded by the Standard Forgings Company for the construction of a new addition to its plant to cost about $15,000.

Iowa

MUSCATINE.—Plans are being prepared by the Continental Serum Company for the construction of a new plant to replace its laboratories recently destroyed by fire. The new works will be located on the site of the former plant in Park Place, and are estimated to cost $50,000. Dr. S. S. Houk is head of the company.

OAKVILLE.—The Hall Air Lock Company has completed arrangements for the leasing of a large foundry building at Granville, Ill., for the manufacture of its products.

Kansas

FREDONIA.—The Fredonia Oil & Gas Company, the Sunshine Oil & Gas Company and other large oil interests, are said to be considering a site in Fredonia for the location of a large new oil refinery.

Maryland

BALTIMORE. — The Continental Can Company, Keyser Building, has had plans prepared for the construction of a new two-story addition, about 35x100 feet, to its works at Orangeville.

BALTIMORE.—Plans are being prepared by the H. E. Crook Company, Inc., Light street, for the reconstruction of its shipbuilding plant at Locust Point recently partially destroyed by fire with loss estimated at $50,000. Howard E. Crook is president.

HAVRE DE GRACE.—The Atlas Powder Company has awarded a contract to the Ley Construction Company, Pittsburgh, Pa., for the erection of a large new chemical manufacturing plant, comprising from thirty-five to forty concrete buildings, including power house, administration buildings and manufacturing units, together with housing and tracking facilities. The entire works are estimated to cost approximately $5,000,000.

LUKE.—The West Virginia Pulp & Paper Company has completed plans and specifications for the proposed new plant which it will erect for the Government to be devoted to the manufacture of industrial alcohol and other chemicals from pulp and paper mill waste. The new works are estimated to cost about $3,000,000.

Massachusetts

CAMBRIDGE.—Fire recently partially destroyed the plant of the American Hard Rubber Company, Potter, Pinney and Ninth streets, with loss estimated at $30,000.

FITCHBURG.—The core department and main foundry building of the Fitchburg Foundry Company were recently damaged by fire, with loss estimated at about $5000. M. J. Perault is manager.

BOSTON.—The works of the Plant Leather Company, 113-17 North street, were recently partially destroyed by fire, with loss estimated at approximately $30,000. The company was engaged on Government contracts.

Michigan

GRAND RAPIDS.—The St. Paul Pioneer Press & Dispatch Company is making rapid progress in extensive improvements in its local paper manufacturing plant, to increase the capacity by approximately 40 per cent. Included in the work is the construction of a new power house, the installation of new generating and manufacturing devices and a new 750 horsepower electric generator. Improvements have been made in the grinder room, and a new cylindrical barker has been installed.

SAGINAW.—The Northwestern Glass Company is planning to inaugurate operations in its new local plant about March 15. About 200 hands will be employed for initial operations. W. G. Edmonds is secretary and treasurer.

Minnesota

MINNEAPOLIS.—The Minneapolis Steel & Machinery Company has taken out a building permit for the construction of a new factory building at East Twenty-ninth street and Snelling avenue, to cost about $28,000

Mississippi

LAUREL.—The plant of the Laurel Oil & Fertilizer Company was partially destroyed by fire recently with loss estimated at about $55,000. It is said the damaged sections will be immediately rebuilt.

Missouri

ST. LOUIS.—The American Manufacturing Company, 1026 South Eleventh street, has had plans prepared for the construction of a new one-story brick and concrete machine shop, about 60x70 feet, at its works at East St. Louis, Ill., to cost about $30,000.

ST. LOUIS.—Fire recently damaged buildings Nos. 9 and 13 at the plant of the Mallinckrodt Chemical Works, manufacturers of chemicals and allied products.

ST. LOUIS.—The St. Louis Malleable Castings Company, Conduit avenue, is considering the construction of a new plant to cost about $50,000.

Montana

HAMILTON.—The Ravalli County Sugar Company, which was recently organized to take over the interests of the Montana-Utah Sugar Company, has postponed the construction of its proposed new sugar factory which is estimated to cost about $750,000, due to the scarcity of labor and materials in this section. V. L. Arnold is local manager.

Nevada

ROCHESTER.—The United States Smelting, Refining & Mining Company has completed arrangements for the taking over and operation of the mines of the Nenzel Crown Point Mining Company. The United States company is planning for the construction of a new mill at the properties and extensive development work.

TONOPAH.—The Belmont Wagner Mining Company is making rapid progress in the construction of a new 300-ton mill at its mines, and it is anticipated that the new plant will be in operation by March 15.

New Jersey

JERSEY CITY.—The George H. Segal Company, 139 Logan street, manufacturer of chemicals, is planning for the reconstruction of its plant recently destroyed by fire.

JERSEY CITY.—The Zibell Damp Resisting Paint Company, 273 Water street, New York, has acquired local property consisting of six city lots on Culver avenue and four lots adjoining on Fisk street, as a site for the construction of a large new plant.

HOBOKEN.—Robert Mayer & Company, Clinton street, manufacturer lithographic inks, etc., has acquired the property of the Prana Carbonic Syphon Company, about 50x100 feet, at Eleventh and Adams streets, to be used as an extension to its works.

NEWARK.—The Verona Chemical Company, Verona and Riverside avenues, has taken out a building permit for the construction of a new one-story brick extension to its plant.

KEARNY.—The Blast Furnace Products Corporation, recently incorporated in Delaware, has acquired the plant formerly occupied by the New Jersey Zinc Company on the Hackensack River, adjoining the Newark Plank Road, Kearney, comprising about 12½ acres, for a consideration said to be about $350,000. The property has a frontage of 930 feet on the river, and is about 915 feet deep, and it is said that the company will use it for the establishment of a new works.

RIDGEFIELD PARK.—The British-American Chemical Company, 52 Vanderbilt avenue, New York, is planning for the construction of new additions to its plant at the site of the Tennessee Copper Company, recently acquired.

PLAINFIELD.—The Niles-Bement-Pond Company, manufacturer of machine tools, is planning for the erection of two new plant buildings at its works to cost about $40,000. The company is also having plans prepared for its proposed new plant on the Kearny meadows near Kearny, on property recently purchased. The works will consist of a group of one and two-story buildings, comprising machine shops, riveting works, erecting shops, etc., and will cost about $2,000,000. The plant will be used for the manufacture of cranes industrial locomotives, and other specialties.

EDGEWOOD.—The United States Government has announced plans for the construction of a large plant for the manufacture of gas, to cost about $35,000,000

New Mexico

MOGOLLON.—The Socorro Mining & Milling Company is making rapid progress in the erection of its new mill, and it is anticipated that operations will be inaugurated around May 1.

New York

NEW YORK.—The Imperial Chemical Manufacturing Company, 135 West Twenty-third street, has leased property at 382 Lafayette street, to provide for increased capacity.

BROOKLYN.—Charles Pfizer & Company, 11 Bartlett street, manufacturers of chemicals, etc., have awarded a contract for alterations and improvements in its plant on Gerry street, near Harrison street, to cost $15,000.

BROOKLYN.—The National Lead Company is having plans prepared for the construction of a new five-story plant, about 95x210 feet, at Marshall, John and Gold streets. The new works are estimated to cost $250,000.

MECHANICVILLE.—Contract has been awarded to the Fuller Construction Company, New York, for the erection of the proposed new plant for the Government to be constructed near the plant of the West Virginia Pulp & Paper Company. The new works will be devoted to the manufacture of acetone, which is used in connection with varnish for the coating of aeroplane wings.

LOCKPORT.—The Upson Company, manufacturer of wall board, has acquired the plant of the St. Clair Paper Company, Capac, Mich., and is planning to dismantle and remove adjacent to its local plant. The consideration was $150,000. The addition will be used for the manufacture of a new fibre product, and will give employment to about 250 additional hands.

BUFFALO.—The Great American Chemical Company, manufacturer of chemicals and allied products, has taken out a building permit for the erection of a new factory building to be located at 284 South Park avenue, to cost about $9000.

North Carolina

GASTONIA.—Fire recently destroyed a portion of the plant of the Rhyne Roller Mill Company, East Gastonia, with loss estimated at $10,000.

LEXINGTON.—The Natural Chemical Products Company, recently incorporated with a capital of $350,000, has completed arrangements for the development of about 500 acres of feldspar deposits in Mitchell County. Contracts have been awarded for the necessary mining machinery and for the chemical equipment for the extraction of potash from the feldspar rock.

RALEIGH.—The Empire Steel Company is planning for the immediate construction of a large new steel plant to have an initial capacity of 100,000 tons. The works will comprise a blooming mill, bar mill, tube mill, and laboratories, with a 10,000 horsepower electric plant. For the present the company will specialize in the production of seamless tubes but are planning for a general steel and iron business. John S. Long is president.

Ohio

CLEVELAND.—The Monarch Brass Company, 1621 East Forty-fifth street, has awarded a contract for the construction of a new one-story foundry, about 90x100 feet, to cost $12,000.

CLEVELAND. — Contracts have been awarded by the Bowler Foundry Company, 1688 Columbus Road, for the construction of a new foundry building, about 75x200 feet, to cost $40,000. The company specializes in the production of iron castings.

SANDUSKY.—The Ohio Tread, Tire & Manufacturing Company, which recently established new offices in the Lawrence Building, is planning for the construction of a large new local plant.

TOLEDO.—The Rex Spray Company, manufacturer of arsenate of lead, recently suffered a loss of about $15,000 on buildings and $50,000 in machinery, etc., in connection with a fire at its plant.

YOUNGSTOWN.—The Sharon Steel Company, which recently took over the plant of the Youngstown Iron & Steel Company, has acquired the furnaces of the Iron & Steel Company, Lowellville, for a consideration said to be $3,000,000. The company is planning to increase its capital from $10,000,000 to $15,000,000, and is considering the construction of additional blast furnaces.

Oklahoma

PICHER.—The Producers' Mining Company is considering plans for the immediate construction of a new 300-ton concentrating plant on a 40-acre tract of lead and zinc properties recently acquired. L. V. Hlvick, Oklahoma City, is president.

TULSA.—The Republic Refining Company is planning for the construction of a new 2500-barrel oil refinery at Jennings. It is said that a pipe line will be laid from Jennings to the Cushing field by way of the Quay plant, which will serve the proposed refinery.

MIAMI.—The Federal Lead & Zinc Company has awarded a contract to Henry M. Martin, Miami, for the construction of a new 300-ton plant. The company has been doing extensive development work on two of its leases, one of 20 acres and another 40 acres, and the new plant will be located on a blocked-out site on the 20-acre lease. The estimated cost is $85,000.

Oregon

GRANTS PASS.—The Gold Hill Manganese Company, recently incorporated with a capital of $1,000,000, is planning for the developing of its four claims on Shan Creek, six miles from Rogue River, including the installation of crushers, jigs, water motor, stamp mill, saw mill, and auxiliary apparatus.

PORTLAND.—Fire recently destroyed the plate room at the plant of the Northwest Steel Company decreasing the operation of the works by about twenty-five per cent. The damage is estimated at about $35,000. The company will commence the rebuilding at once. J. R. Bowles is president.

Pennsylvania

GLENSHAW.—The Glenshaw Glass Company has commenced the reconstruction of its one-story plant, about 75x100 and 50x100 feet, respectively, recently destroyed by fire.

PHILADELPHIA.—The Philadelphia Paper Manufacturing Company has acquired property adjoining its plant on River road in the Manayunk section for a consideration of $25,000. It is said the new property will be used for extensions.

PHILADELPHIA. — The Nitrogenous Chemical Company is having plans prepared for the construction of a new one-story brick and concrete plant at Thirty-seventh and Tasker avenues, to be devoted to the manufacture of sulphuric acid.

PHILADELPHIA.—The United States Conditioning and Testing Company has completed its enlargement plans at its chemical laboratory, to provide for increased capacity.

HUNTINGTON.—The Aetna Explosives & Chemical Company is planning for the immediate construction of new additions to its plant at Mount Union for the manufacture of smokeless powder. The extensions are estimated to cost $500,000. The new plant will be especially adapted for the manufacture of dyes and chemicals after the close of the war.

PITTSBURGH.—Fire recently caused a loss of about $25,000 in the plant of the United States Glass Company, Winnebago street, South Side section, Factory A.

Texas

TOYAH.—The Toyah Texas Sulphur Company, recently incorporated with a capital of $350,000, is planning for the immediate development of about 600 acres for the production of sulphur. A large new plant will be erected. James C. Buchanon is president.

EL PASO.—The Kansas City Smelting & Refining Company has completed extensive improvements at its local plant at an estimated cost of about $1,000,000, including a new copper blast furnace, two new converters and new mechanical ore conveyor.

Utah

MARYSVALE.—The American Agricultural Potash Company has inaugurated operations in the second alunite potash mill of the Florence Mining & Milling Company, and two additional mills are now in course of construction.

SALT LAKE CITY.—The Standard Oil Shale Company is planning for the construction of a large new plant at Elko comprising a new refinery and a distillation retort with a daily capacity of about 100 tons. Professor Otto Stahlman is consulting engineer for the company.

FISH SPRINGS.—Daniel Livingston, J. A. Rich, and associates, have acquired the plant and properties of the Utah Mining Company, and are planning for the construction of a new concentrating plant.

Wisconsin

MILWAUKEE.—The George H. Smith Steel Casting Company has taken out a building permit for the erection of a new foundry and office building at Clinton street and Greenfield avenue, to cost $50,000.

ANTIGO.—Mayer Brothers, specializing in the manufacture of power hammers, have taken over the plant of the Kaukauna Machine Works, and have filed notice of a change in its corporate name to the Kaukauna Machine Works Company.

Canada

KIRKLAND, ONTARIO. — The Teck-Hughes Mining Company is making extensive improvements in its mill to increase the capacity and improve the recovery.

PORT MOODY, B. C.—The Aetna Steel Works are planning for the installation of a new six-ton electric smelter furnace.

PRINCETON, B. C.—The Canada Copper Company is planning for the immediate construction of a new 3000-ton concentrating plant. Power for the operation of the works will be furnished by the West Kootenay Power & Light Company, Trail, which will extend its electric transmission system to this plant.

ANYON, B. C.—The Granby Consolidated Mining, Smelting & Power Company, is making extensive improvements at its local copper mines, including the installation of new converters to increase the capacity from 75,000 to 85,000 tons per month. The company is also constructing by-product coke ovens at the plant to have a capacity of 350 tons of coke and 500 tons of coal daily. The work is estimated to cost $1,-500,000.

Trade Notes

GRASSELLI CHEMICAL EARNINGS. — The Grasselli Chemical Company reports that net earnings for the year 1917 of approximately $4,300,000, against $9,935,000 in 1916, $4,859,000 in 1915 and $1,680,000 in 1914. The stockholders have voted to approve the proposal to increase the stock to $50,000,000, of which $35,000,000 will be common and the remainder preferred.

GENERAL CHEMICAL EARNINGS.—The General Chemical Company saved a net profit last year of $7,671,151 from a gross return amounting to $14,694,686, after setting aside $1,800,000 for Government war taxes and making substantial reservations for insurance and depreciation. In 1916 the profit was $2,024,000 larger, although taxes then were much smaller. The surplus for 1917 after dividends had been paid was $4,320,-160, and the total surplus was $15,719,170, against $11,399,010 a year before.

ERICHSEN SHEET METAL TESTING MACHINE.—Herman A. Holz, 1 Madison Avenue, New York, owner of the American rights to the Erichsen patent, announces that the patent was reissued to Mr. Erichsen on Jan. 8, 1918 (No. 14,421).

MINERALS SEPARATION NORTH AMERICAN CORPORATION announce the removal of their San Francisco office and testing laboratory from the Merchants Exchange Building to 520 Battery Street, where they have established an ore-testing works.

THE ASBESTOS PROTECTED METAL CO. of Pittsburgh announces the removal of its Boston office to the State Mutual Building, to be in charge of Mr. William H. Cummings.

AMERICAN NAMES FOR AMERICAN DYES.—John Campbell & Co., 75 Hudson Street, New York, have issued a pamphlet on colors in which pertinent recommendations are made for the American dyestuff industry. The concluding part of the pamphlet says:

"Every American manufacturer of dyestuffs should give to his colors an appropriate name. We should get away from the habit of referring to American colors by foreign names. In a comparatively short time we have produced colors that are equal to, and in many instances better than, the so-called German standards. It is only a question of time when the fastest, rarest, and most intricate dyes will be produced in this country.

"Now, the American consumer will never willingly put himself in the position he occupied when the war shut off the supply of German colors. He realizes the necessity of having a dependable source of supply at home, and the only way this can be done is for the consumer of dyes to support the American dyestuffs manufacturer. No American mill man should use the German trade words for the names by which he has known colors in the past. To do so would be playing right into the hands of the German business propagandist. Therefore, let us be loyal to everything American, and among other things designate the American colors by their American names."

LOW-VISIBILITY PAINTS.—The latest issue of *Graphite*, the house-organ of the Jos. Dixon Crucible Co. of Jersey City, states that commercial ships are now also painted so that they blend with misty weather and with the horizon. The company manufactures natural and olive green silica-graphite paints for this purpose.

THE HOLCROFT & LANE CO., Detroit, Mich., which has built core and mold ovens for the H. M. Lane Co., also of Detroit, has changed its name to Holcroft & Co. They will continue as a purely contracting organization and have made arrangements with the H. M. Lane Company for their engineering, consulting and drafting work. The operations of the two companies, however, have been entirely divorced, and Holcroft & Company are now located at 555 Book Building, Detroit, Mich. The latter company also makes open-hearth and miscellaneous metallurgical furnaces.

DRIVER-HARRIS COMPANY, Harrison, N. J., on the night of Jan. 31, suffered a loss of fire of their insulated wire and electrical cord departments. These buildings have been completely destroyed. The company's business in production of resistance materials, castings, cold rolled strip, nickel sheet and other products is not interfered with.

NEW OFFICE FOR NATIONAL ANILINE.—A new office building at 21 Burling Slip, New York, will be occupied about May 1, 1918, by the National Aniline & Chemical Co., whose office at present is at 244 Madison Avenue. The new building, acquired through the Century Colors Corporation, one of the constituent companies of the National Aniline & Chemical Company, Inc., has long been known as the best equipped and most modern of dyestuffs headquarters anywhere outside of Germany. Prior to the war it was the headquarters for the distribution of dyes produced in Germany by Leopold Cassella & Company. But whereas during this period but four stories were used for office, laboratory, and clerical purposes, the National Company, together with the Century Colors Corporation, will occupy the entire ten floors for these purposes, in a thoroughly re-equipped building, with the entrance on Burling Slip. It is near the main offices of the General Chemical Company, the Barrett Manufacturing Company, the New Jersey Zinc Company, and other great chemical concerns.

FINE PLATINUM WIRE.—The Richardson Research Laboratory of Cleveland announces that it has succeeded in making a fine platinum wire to take the place of spider web for cross hairs in telescopes, etc. Platinum wire shipped to their customers recently is reported to be 0.000975 in. in diameter.

THE DURIRON CASTINGS COMPANY of Dayton, Ohio, manufacturers of Duriron, acid-alkali-rust-proof apparatus, announces the removal of its Chicago office to the Harris Trust Building, to continue in charge of Mr. George A. Cocup.

GOLDSCHMIDT COMPANIES COMBINE.—Announcement is made that the business of both the Goldschmidt Detinning Company and the Goldschmidt Thermit Company will hereafter be conducted by the "Metal and Thermit Corporation" with general offices at 120 Broadway, New York. These two concerns have been practically combined for the last two years and have occupied joint offices at the above address. The combination, which is controlled exclusively by Americans, has now been put in more permanent form as it is felt that this will tend towards greater efficiency and co-ordination of effort.

The detinning department of the Metal and Thermit Corporation will carry on one of the largest industries of its kind in the world, i. e., the recovering of tin from tin scrap. Approximately 4,000,000 tons of tin scrap is treated yearly by this department and the recovery approximates the equivalent of 2000 gross tons of metallic tin. The output of this branch of the corporation consists of pig tin of a quality equalling Straits tin, tetrachloride of tin and detinned billets, the latter being the iron scrap after the tin is removed.

In addition to its line of carbon-free metals and alloys, the company produces pure tungsten powder in very considerable quantity. It is also selling agent for the output of a large plant in the middle West producing 50 per cent electric furnace ferro-silicon.

The Thermit welding proces is used by many of the railroads in the United States and Canada for welding broken locomotive frames and other heavy sections. It is also used very extensively by the different steel mills for welding broken equipment, such as rolls, pinions, crank shafts, etc. The process is extensively employed for the welding of rails for trolley lines, the welding of broken sternposts and rudder frames of steamships.

The Metal and Thermit Corporation operates four different plants located respectively in Jersey City, Chrome, N. J., Wyandotte, Mich., and Chicago, Ind. The Chrome and East Chicago plants are devoted to the detinning industry; the Wyandotte plant to the production of liquid chlorine, and the Jersey City plant to the Thermit products, including welding materials, carbon-free metals and alloys and pure tungsten powder. The corporation operates branch offices and welding shops in Pittsburgh, Chicago, San Francisco and Toronto.

The following are the officers and directors: W. T. Graham, Edgar L. Marston, Daniel G. Reid, F. S. Wheeler, Huhert E. Rogers, F. H. Hirschland, E. L. Ballard, L. A. Welles, Charles F. Dane, Philipp Gensheimer, Fred W. Cohen.

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Playing with Platinum Prices

THERE are some metals of such limited known distribution in the earth's surface that their economics are comparatively simple and easy of comprehension. Platinum is one of them. Produced for the major part in the Urals of Russia, and latterly to an important extent in Colombia, the metal is recovered only incidentally elsewhere. With the Russian supply curtailed, if not entirely cut off, the prospect for platinum in plenty is not alluring, and Colombian sources assume an aspect of greater importance.

The supply of platinum in the United States may fall short of demand; at least that is a fair inference from the order of the War Industries Board, which we publish elsewhere, commandeering platinum supplies in this country. Putting together the facts just stated, *viz.*, that we face a platinum shortage and that the only places from which we can get it in quantity are Russia and Colombia, it would seem to be fair business sagacity to offer an inducement for the production of platinum and its shipment to this country. At least we should not deliberately place any obstacles in the way.

For over a year the prices of platinum have been fairly stable at $103 @ $105 per ounce. We are informed, however, that the War Industries Board proposes to pay only $90 per ounce for the 20,000-oz. lot brought from Petrograd some months ago by Mr. Draper. Presumably if so inconsiderate a proposal is made in this instance, domestic dealers who have no alternative will fare no better. We may now frame a simple question: Under the conditions just outlined, how much platinum will the War Industries Board be likely to get? The answer seems equally simple: Just about the available stock now in the United States, *and no more.* And yet we face a shortage of platinum, and produce practically none of it in this country.

Within the period of the war it has been amply demonstrated that economic laws still work in the case of needed metals. The memory of the tungsten boom is still fresh in the minds of many. Tungsten was suddenly needed in large quantities. The price rose rapidly and became so attractive that people literally combed the hills of Boulder county, Colorado, getting a bucketfull of high-grade float in the course of a few days. A great deal of the mining was crude and much of the milling was wasteful; but we got tungsten, and the price stayed up until it attracted supplies from Burma and other foreign countries where the mineral was laboriously accumulated by natives. Even their simple wants could not be met by shipping tungsten to this country when the market was normal. It took a stimulus in the form of a high price to make them active producers. Supplies having been brought out plentifully, the price fell off and has remained down ever since. We commend the incident to the War Industries Board.

Post-Mortem Reports

METALLURGISTS are agreed, privately, that a public record of failures and negative results would be quite as beneficial to the profession as the more customary announcement of successes. For this reason we consider it important to publish in this issue an account of a careful but unsuccessful effort to treat sulphide copper ores with nitric acid. Mr. Westby is to be commended not only for a clear discussion of the chemistry of the method, but for a frank revelation of an unsuccessful attempt to supply a process which had gained considerable notoriety in the West and which was heralded as a solution of some of our metallurgical problems.

A striking point among the reasons for failure was the inability to make a complete recovery of the solvent —nitric acid. The commercial meaning of even a three per cent loss was painfully evident when costs were estimated. The results of ten tests with laboratory apparatus indicated an average nitric acid recovery of 90.5 per cent and an average copper extraction of 88.9 per cent. The former is distinctly poor and the latter not strikingly good. In large-scale tests the results were not nearly so good. Compared with roasting and leaching with sulphuric acid, the nitric acid process held no attractions in estimated profits, for under the most favorable assumptions of recovery of acid and copper the nitric acid process showed an estimated net profit of only $2.46 per ton as against $3.27 by roasting and leaching with sulphuric acid.

Iron and Steel Price-Fixing

THE iron and steel industry is quite accustomed to kaleidoscopic changes, and war brings its own sudden and great changes, so that it is not surprising that conditions in the steel industry are radically different from those that obtained six months and twelve months ago. A year ago steel prices were trending upwards very sharply indeed. To-day the question is whether the War Industries Board will seek lower prices for the next period, the present set prices having been, by the announcement of last December, extended to March 31. On an average, the present set prices are approximately at the same level as the market of one year ago. Price-setting simply eliminated the additional advances that occurred March to June inclusive of last year.

There are, in essence, two important changes that have occurred in the position of the War Industries Board which, with the President's approval, represents the government. The first change is really the absence of a change that was expected to occur. Last December, when the War Industries Board approved an extension of the set prices to March 31 of this year, the expectation was entertained that long before the new date had arrived the Pomerene or some other iron and steel price-fixing bill would have passed Congress. The authorities at Washington expected they would have some legal authority over iron and steel prices in general, of somewhat the same character as the authority that was given by the Lever act of August, 1917, with respect to "food, feed and fuel." The proposed legislation was dropped, however, partly, no doubt, because Congress has been so busy—in the Congressional sense —with other legislation that it could not consider iron and steel, but partly also, beyond question, because the iron and steel industry was found so ready to follow instructions or requests, no matter upon what authority they rested, that legal enactment did not seem necessary. Thus the War Industries Board to-day is without a legal authority that it was expected to possess by this time.

The other important change is that the tactical position of the government in this matter is altogether altered. During the months in which a voluntary agreement—the expression may be somewhat tautological but it is sanctioned by usage—was sought, the position of the steel makers was that government orders were accepted solely as a patriotic duty while ordinary commercial orders represented a much larger tonnage and much higher prices.

By legislation enacted before the war started, the government was empowered to fix "fair" prices upon any material it bought. For a time the view of the steel industry was that the government should go ahead and fix prices on its purchases, leaving the industry to fix its own prices on the steel sold to the general public. The latter represented by far the larger tonnage. President Wilson insisted this would not do, that there should be "one price for all." Finally he enunciated his views in a very clear and direct statement, July 12, which statement was received with much consternation and some criticism, but has since been tacitly accepted universally as a necessary and eminently proper rule of conduct.

Nine months ago the iron and steel market was still "going strong." With the government empowered to fix prices on the material it bought, and on nothing else, to propose that there should be one price for all seemed like proposing that the tail should wag the dog. Since then there has been a complete reversal. If the government were now to fix prices upon all material required for the war and leave producers to name prices themselves upon all other material the government would be fixing prices upon the bulk of the material, not upon a minor part. It has taken over the railroads, and it could go farther and take over bodily the petroleum industry, the motor car industry, and some others, leaving little steel consumed on the outside, when building operations for peace purchases have dwindled to insignificant proportions. Thus the War Industries Board is now so well fortified that apart from considerations of patriotism it is practically in control.

There is in fact no question of authority and no general divergence of opinion. The matter of iron and steel prices has become purely one of expediency, what is best for the country. On the one hand, the prices to be paid for pig iron or steel should not be exorbitant, whether it is the government, its Allies, or the general consuming public that is the buyer. On the other hand, prices should be such as to afford reasonable profits to the manufacturers, not to the few, but to the great majority, to all except those manifestly inefficient. The government elected to obtain a large part of its war chest by taxation, and elected furthermore to tax production rather than consumption. There must be profits to be taxed or the scheme falls to the ground.

Conditions have been such in recent months, with greatly restricted output and correspondingly mounting costs, and costs varying widely from week to week and from plant to plant, that it is a practical impossi-

bility at the moment to determine closely what is a fair price. Compared with some recent costs the present prices may be too low. By other comparisons they may appear too high. The industry hopes for better operations and steadier costs even in the next few weeks now that the season has changed. The wise course will probably be to let the present price structure stand without disturbance for a time at least.

The Crystal-Gazer

THE crystal-gazer who could read the past, present and future of the world by concentrating his attention upon a small silvered ball, has his scientific counterpart in the metallographist who cuts a few ounces of metal from the lining of a huge rifle, gazes at these fragments through his microscope, and proceeds to reconstruct the behavior of the sixty-ton bulk during and after the lightning flash of powder and shell. Who shall attempt to predict the limits to the metallographer's domain when some studies in the quiet of laboratory and library reveal the metal's travail during catastrophic explosions?

A most striking example of the efficacy of accurate observation and clear reasoning in the solution of the problems of industry is presented in a paper on "The Erosion of Guns" read at the New York meeting of the American Institute of Mining Engineers by that remarkable American, Henry M. Howe. We published a summary in our last issue, but for the entire article we bespeak the closest study. Even the non-metallurgical reader can admire this investigation for its sheer beauty, while the metallurgist will derive inspiration and courage in this evidence of the important work which is possible even with a moderate amount of instrumental equipment when reinforced with a large amount of intellectual resource.

Ammonia, Refrigeration and Munitions

A VERY serious need just now is that of ammonia. There is a demand for it by the government so great as to tax every possible source of supply, and the question may soon have to be met as to where the use of ammonia may be curtailed. The United States Government requirements for May, 1918, are three times, and for December, 1918, seven times its requirements for February of this year; but government nitrate-producing plants are under construction and it is hoped that they may be completed in time to avert any serious dislocation of industry.

The largest industrial use is for refrigeration. Of the 6,000,000 tons of ice annually used in New York City, for example, about one-half is artificial. Ten cities of the United States produce annually about 8,000,000 tons of artificial ice, and most of this is refrigeration by the ammonia process.

The United States Food Administration is taking the matter in hand and is urging with energy the harvesting of natural ice wherever possible, and hints and directions for doing this are sent broadcast. Ice-producing plants are urged to co-operate for the saving of ammonia and fuel, and such co-operating parties are urged to avoid legal complications or the infringement of anti-trust laws by conferring with local officials in this emergency. All refrigeration establishments are urged to stop losses of ammonia, to eliminate corroding factors from their circulating liquors, to return empty cylinders to supply firms and to harvest all the natural ice they can. Every coal-gas plant that consumes over 5000 tons of coal per year is urged to save its ammoniacal by-products. Parties contemplating the erection of new artificial ice plants have been addressed by the Food Administration through its Division of Chemicals, pointing out the pressing need of ammonia for munitions and its prospective shortage. They are urged to postpone such undertakings. Over a dozen booklets have been prepared and are distributed to municipalities on the safe and proper use of natural ice. Trading in ammonia, ammonium sulphate and ammoniacal liquors in quantity has been placed under license, and manufacturers are cautioned not to buy over 60 days' supply. Hoarding will be punished by cutting off the entire supply.

From the foregoing it will be observed that Mr. Charles W. Merrill, chief of the Division of Chemicals of the U. S. Food Administration, is not letting the grass grow under his feet.

The only trouble with substituting CO_2 and SO_2 for NH_3 in plants which are designed for the use of ammonia is that in the present state of the art it can't be done. The compression pressure required for ammonia is from 185 to 200 lb. per square inch. For carbon dioxide from 1000 to 1200 lb. is needed. It stands to reason that apparatus built to withstand 200 lb. will not endure 1200. The compression pressure required for sulphurous oxide is low, but the pump and refrigeration pipes must be made of brass or copper for obvious reasons. SO_2 does not behave well in iron and on the other hand NH_3 gets nervous in copper or brass. There does not seem to be any way available in the light of present knowledge to shift from ammonia to carbon dioxide or sulphurous oxide or any other gas in ammonia refrigeration apparatus. And considering the need of mechanics in the industry of war, new equipment is not available.

Large quantities of ammonium nitrate are used in domestic explosives. Under normal conditions, produced at an expense of 6 or 7 cents per pound, it is the cheapest explosive ingredient of blasting powder. With glycerine at 60 to 65 cents a pound, and almost impossible to get at that, the use of high explosives for this purpose is prevented and a heavy burden as well as a serious problem is placed upon the mining interests. The conversion of starch to glycerine is still very indefinite. It has not yet reached an economic stage.

There are certain economies proposed by Col. Walker that do not come under such close surveillance as those industries under observation of the Food Administration, and to these we not only call the attention of our readers but invite suggestions as to the best methods of carrying them out.

Old, exhausted, dry batteries are usually thrown away. This is a serious waste, as they still contain 80 per cent of their ammonium chloride and all of their manganese dioxide. If these were exchanged when new ones are purchased, instead of thrown away, an economy in charging and in the use of ammonia would be effected. Galvanizing works also are large users of ammonium chloride, and one has but to enter them to see waste in many instances. In the preparation of soldering fluids and fluxes the use of ammonium chloride should be discouraged as far as possible.

Readers' Views and Comments

Co-ordinating Production and Transportation

To the Editor of Metallurgical & Chemical Engineering

SIR:—There are indications on all sides that we are approaching an industrial and economic crisis. One of the most evident signs of this is the amount of criticism which is being showered on those in charge of Government activities, nearly all of which at present relate to the war. The attempts to blame these various inefficiencies on individuals are being made on all sides. It was only natural in this confusion that army officers and Government officials in general should be the first to receive the blow, for we have always held the theory that Government officials were far more inefficient than our business men.

The number of applications from private manufacturers for the help of "efficiency engineers," which has so largely increased lately, is indicative of a realization on the part of many of our manufacturers that their methods also are not what they should be. The people who are applying for help are, in many cases, no worse off as far as their methods are concerned than others who haven't yet discovered how badly they are doing their work. The whole subject seems to resolve itself into the fact that our business and industrial systems are not suited for times like these, when it is necessary to combine all our energies and exert our full driving power toward the achievement of one supreme object.

We should not be surprised that this is the case, for our economic theory has never contemplated teaming up all the industries of this country for one object, but has rather discouraged that idea and encouraged individual competition of the most strenuous kind. In other words, we are a nation of individualists who have never really seriously contemplated coöperation for the common good.

Past Training Unsuited to Present Needs

When this problem of coöperation is suddenly put up to us as it has been by the war, it is not surprising that our business men, trained in the individualistic school, should be entirely unfitted to solve the new problem. Moreover, it might be expected that the men who have been most successful in individualistic, competitive business, in which profit was the main aim, should be actually the ones least fitted to establish a scheme of business and production for the benefit of the community. This is a new problem to them, and one altogether outside of their experience.

It is to be granted that such business men may have individually great driving power, but this very excess of driving power in individuals or corporations is likely to make the confusion all the worse, unless a means of co-ordination is established which will keep the driving power of the individuals or corporations in proper balance.

It has become perfectly evident to all observers that the capacity of the nation for production of war material is enormously greater than its capacity for shipping it to Europe, and that we must at once not only balance this production, but slow it down in order to prevent such a choking of our eastern ports as may produce an impossible condition. The five-day shutdown ordered by the fuel administrator and the one-day-per-week shutdown are our first attempts to slow up this production, and we ask ourselves at once if this is the best way. The answer comes that if we are making too much war material we had better turn some of our activities into the manufacture of articles of peace. Immediately we run into the financial situation, which at present seems to seriously hamper new undertakings.

It would seem that the claim of the railroads that they need $1,000,000,000 worth of improvements should at this juncture be considered. Here is one organization now devoted exclusively to the service of the community which, being under the control of the Federal Government, can be financed directly by that government, and there would seem no reason why the production programs of war material should not be limited, and a certain amount of the energy now being expended in that direction turned at once toward the improvement of our transportation facilities.

This is the first suggestion that occurs to one as a means of avoiding the economic situation which seems to be forcing itself upon us. If we can afford to spend billions for war, should not our Government be authorized at once to turn whatever surplus energy has been inadvisedly called into this work into channels that will be beneficial to the community in time of peace?

Overproduction a Menace

After nine months of confusion, it is becoming perfectly clear that as far as we are concerned, in this country at least, our war problem is one of production and transportation on a huge scale.

The critical point to-day is recognized on all sides to be our ability to transport material to Europe. We have in the past repeatedly had estimates as to what transportation facilities we should have, but it is only recently that any real attempt has been made to study the transportation problem thoroughly and to find out what the limiting factors were and how they could be improved. It is hoped that through the investigation which is now being made we shall shortly have exact knowledge on this subject.

In the meantime, however, we already have approximate knowledge which indicates that our production of war material is rapidly outrunning the possibilities of transportation.

Early in December Dean Schneider, working for the Ordnance Department of the army in Washington, warned General Wheeler, Acting Chief of Ordnance, of the situation which is now impending, and the Ordnance Department began promptly to investigate the subject. Investigations of this subject by one department, however, are not sufficient. Our whole production program must be harmonized with the possibilities of over-seas transportation. In other words, an attempt should be made at once to balance our production of war material of all classes with the possibilities

of transportation, and wherever necessary the production program should be slowed down at once in order that the congestion on our Atlantic seaboard may be relieved. The slowing down of this program means that energies which have been unwisely directed to war activities must be at once transferred back again to the industrial work which has to do with peace and the upkeep of our industrial organization.

This is necessary for two reasons:

First: If we are going to spend fifteen billions per year in war we must produce at least fifteen billions more material than we need for peace times, which means that our working plant must be kept in the best possible condition.

Second: If we do not realize that by the production of a surplus of war material we shall ultimately be compelled to cease that kind of manufacture and thereby suddenly throw out of work large numbers of men, we may precipitate an economic crisis of great magnitude.

H. L. GANNT.

Engineers in Training

To the Editor of Metallurgical & Chemical Engineering

SIR:—In the December 15, 1917, issue of your publication appeared an article by Robert Tudor Hill on "Engineers in Training." Professor Hill's orderly presentation of the subject and his carefully compiled tabular illustrations naturally attract the attention of one who is interested in educational work. This is especially true if one has had opportunity to observe and ponder over several of the conditions and tendencies to which Professor Hill calls attention.

Readjustment of Engineering Courses

It appears that in many technical schools the broader engineering courses are undergoing a process of remodeling and readjustment from year to year. Several factors are responsible for this variation. Every up-to-date engineering course must keep pace with developments in practice. Both equipment and methods of doing things are improving and changing at frequent intervals. The engineering course which is not adjusted to meet these conditions is not only subject to unfavorable comment from any interested critic, but rapidly becomes uninteresting to the wide-awake student who is beginning to take a serious interest in the field activities of his chosen profession. Therefore, improvement in engineering practice will compel a continual revision of engineering courses.

Another factor which disturbs the stability of an engineering course in some institutions is a process of experimentation which may be described as a struggle to reconcile two opposing tendencies, viz., on one hand to inject into a course the maximum amount of discussion of fundamental theory involved in the subject under presentation, and on the other hand to include in the instruction as many as possible of the so-called professional tricks or kinks used in practice. The first mentioned extreme may make the subject so dry and uninteresting to the average student that he will deny it the attention it deserves, and he may fail to absorb certain important ideas which would be devoured with pleasure if administered in more palatable form. On the other hand, an effort to present innumerable practical frills with the consequent crowding out of valuable fundamental theory results in defeating the very object of ideal instruction, which is to inculcate ability to think properly in the face of an indefinite variety of emergencies, rather than learn how to perform a limited number of set tasks. The young engineer who has a firm grasp on fundamental theory is equipped for professional growth and expansion, and is likely to develop into a citizen of ever-increasing usefulness. The technical graduate who is short on theory may develop cleverness in solving certain problems, but he is likely to lack versatility, his growth may be limited, and he may fail to become more than a first-class mechanic in certain technical activities. The difference between these two products may be chargeable, in part at least, to faulty or inefficient technical training or instruction.

Importance of Study of Economics

If the object of technical education is to develop professional ability calculated to increase industrial efficiency, then no presentation of an engineering problem is complete unless it has been discussed critically from an economic viewpoint. Every engineering project which requires the expenditure of money and contemplates the return of this money together with a profit commensurate with the risks involved, is essentially an economic problem and the technical features are really secondary in importance. If the project will not satisfy a critical investigation from a commonsense, business standpoint, the most interesting technical possibilities of the undertaking are of little consequence. In view of the variety and complexity of the economic factors which frequently demand consideration in passing judgment upon important industrial undertakings, it appears that there is little danger of including too much study of economics in engineering training. It has been pretty well demonstrated that in order to become a safe engineer the technically trained man must first be a good business man.

Consolidation and Expansion of Courses

In the development of engineering courses there are two dangerous extremes which most technical schools endeavor to avoid. Tendency toward these two dangers is a natural consequence of the institution's struggle to crowd the maximum quantity of information into a student in the minimum length of time. This is usually a more serious problem for state institutions, on account of the misdirected and ill-advised political pressure which is sometimes brought to bear upon the governing authorities of the institution. A common example is the school that is compelled to receive the poorly prepared product of the average high school and transform him into the making-of-an-engineer within a period of four years' technical training.

The struggle to meet this condition, and at the same time keep pace with developments in practice, frequently results in the undue expansion of certain courses of study until a definite quantity of useful knowledge is spread out in a thin layer over a considerable period of time. Frequently in this development the apparent improvement in one course is accomplished at the expense of another. A standard and well-balanced course may be forced to concentrate until the time allotted thereto becomes inadequate for the thorough presentation of fundamental principles. This

process may result on one hand in dilation which is nothing but dilution, and on the other hand in concentration which degenerates into a smattering.

Danger of Extreme Specialization

Another struggle between two tendencies is frequently apparent in technical schools, viz., either to produce a jack-of-all-trades who has studied *at* so many different subjects that he has no useful working knowledge of any, or to develop in some one line of investigation such a highly specialized product that his general usefulness in the world is confined within very narrow limits.

It is frequently said that we live in an age of specialization. This is true, but the remark contemplates specialization within sane limits. In this connection it may be fair to observe that the average high school graduate who elects to attend a technical school is usually more mature mentally than the one who decides to follow a liberal arts course. One has decided upon his profession, or has at least determined the general line of activity for which he is best fitted, while the other is still wavering, and may not yet have developed any definite ideas or ambitions as to his probable future career.

This observation by no means assumes that the man who has tentatively chosen his profession is the more intellectual of the two, nor does it assume that he is correct in his estimate of his fitness for the work he has chosen. He may be utterly lacking in certain characteristics which go to make up a successful engineer. A man does not always find his best opportunities in the special vocation which he has chosen. Frequently a technical graduate who has devoted much effort to a certain line of endeavor, and has gained valuable experience therein, finds himself face to face with an attractive opportunity for growth and expansion in some radically different occupation, to say nothing of possible commercial advantages of such a change of labor. This case suggests the advantage of developing in the technical student, so far as possible, a degree of versatility which will relieve him of the necessity of depending upon a single accomplishment for his professional usefulness or advancement.

A frequent danger of specialization, especially in engineering professions, is for the student, and later the engineer, to become what is commonly called narrow. During the intensive study of technical and scientific subjects the student may have absolutely neglected his non-technical education, to his ultimate serious disadvantage in most cases. Usually little or no time is provided for the further study of English or other modern languages, no effort is made to develop ability in technical writing or in business correspondence. The idea that a technical man has a right to acquire a taste for good literature, or that his general cultural development is likely to have a vital influence on his professional career, is frequently ignored in designing a curriculum. Certainly it is a fact that the advantages of developing in an engineer those qualities which are associated with ideas of culture and refinement are seldom even thought of, at least by the student who must later on suffer because of this neglect. Most interested observers can recall more than one case of an engineer who is thoroughly competent in certain technical and business activities, but who is severely handicapped and misjudged because he appears to be positively illiterate.

Preparatory Schools Deficient

A young engineer's ability to seize and make the most of his opportunities may be due to the training he received in high school, where certain tendencies, or habits of thought, or fundamental qualities or ideals were developed and cultivated. Right here in the high school is one of the most important periods of a young man's education. For the student who intends to go to college or university it is of vital consequence. While the high school is in many respects the most important link in our educational system, it is at the same time the weakest. The average high school throws away its opportunity. Lucky is the technical man who has learned in his high school course how to speak and write his native language correctly and has mastered elementary mathematics, physics and chemistry. Many an engineer owes his cultural accomplishments and his taste for good literature, which are a never ending source of satisfaction and advantage, entirely to his high school instruction. Unfortunate is the technical school man who has been denied the refining and broadening influence of an efficient high school course. Few technical schools have time, or take time, to supply the kind of instruction and training that marks their graduates as men of liberal education.

Observation of modern tendencies in high school instruction is not reassuring to the seriously interested critic. During the past fifteen years or more almost all high school courses, which were formerly calculated to prepare the student for university training, have sadly degenerated. High school teachers of long experience, who are disposed to be frank in the matter, admit this to be true. There is a growing disposition to let down the former standards to the extent that the university finds it necessary to devote undue time and attention to the review of many subjects which should have been mastered in a preparatory school. This degeneration appears more serious when we realize that a large proportion of young Americans never complete or pass beyond their high school course, and that with deficient instruction the high school is losing its last opportunity to impart valuable knowledge to future citizens. High schools seem to have developed a policy of graduating the greatest possible number without regard to quality of work. To some extent this policy is forced upon the high school by the tax-paying public which demands that the school increase its sphere of usefulness by imparting a little more knowledge to a great number of future citizens. The so-called vocational training movement has done much to lower the general quality and standards of high school instruction, and to diminish its usefulness as a preparatory school for those who contemplate higher education. This observation is not intended to imply that vocational training in the high school, and its effort to turn out more graduates of poorer average quality is wrong from every viewpoint. If we adopt as our guiding principle "the greatest good to the greatest number," then the modern tendencies in high school instruction may be admirable in theory. Advocates of this principle point out that relatively few high school graduates go to the university, and hence it is unfair to regulate high school standards for the benefit of the

minority. There is little consolation in this argument for those who do contemplate higher education, and the suggestion is made that these students should receive separate or supplementary instruction calculated to supply their needs. While it may be admirable to increase the number of slightly better educated citizens by designing high school instruction to fit their requirements and capacities, it is also important to look to the welfare of that less numerous class that continues its development, and from which many of our leaders of thought are destined to be chosen.

Conclusions

The above informal and somewhat rambling observations lead naturally to the conclusions reached by Professor Hill. All of his eight conclusions are interesting and worthy of careful consideration, not only by designers of technical curricula but also by those who have power to influence the efficiency of the preparatory school training. Preparatory schools should give most serious attention to his conclusion No. 5, which states: "Readjustments in preparatory and earlier secondary school training are desirable so that preliminary training may be completed earlier. This will save time below and gain time above." In other less elegant words, our educational system would be greatly improved if the average high school would do its duty and quit "passing the buck" to the university. Again, the technical school should take to heart his conclusion No. 8, which is in part: "Non-technical instruction for technical students must be as efficient as technical instruction." It is to be hoped that technical schools will interpret these words to mean that it is worth their while, from selfish as well as altruistic motives, to make every reasonable effort to produce "well-informed business gentlemen" rather than "crude skilled technicians."

Harry J. Wolf.

Denver, Colorado.

Origin of the Nebraska Potash Lakes

To the Editor of Metallurgical & Chemical Engineering

Sir:—The very evident interest which the chemists of the United States are bestowing upon potash products and the importance of the Nebraska Lakes has emboldened me to write you a somewhat geological letter dissenting from the usual views held as to the source of the solutions in the saline lakes which are now providing the bulk of this country's available potash. This question is of great importance, since the accepted views set forth in your recent article on "The Nebraska Potash Industry" (Metallurgical and Chemical Engineering, Vol. 17, p. 673, Dec. 15, 1917) that the lakes are merely concentrations of wind-borne plant ashes, give a distinct limit to the amount of potash available from this source. An intensive study of the sand-hills region and its vicinity has brought so many facts to light which are at variance with this hypothesis that I have concluded that the source of the potash is from ground waters circulating through the underlying sands. If this be true, the amount of available material is enormously greater than possible under the former hypothesis. I base my theory on the following observed facts:

Following the upheaval of the Rocky Mountains were numerous periods of erosion and deposition. The material being eroded from the slopes was carried eastward from the divide and deposited in an inland sea covering what is now the High Plains area. The product of this entire period formed rocks and strata in that region which we now term the Tertiary series. There are some fifteen members of the Tertiary, all being conglomerates, varying chiefly in the predominance of lime or silica present. Thus some of them, such as those called the Niobrara by the geologist, are limestones, while the Arikaree and Ogalalla are calcareous sandstones.

As the inland sea receded, erosion of the lake bottom commenced, and the present sand-hill area was formed from these calcareous sandstones by the simple process of the removal of the cementing material by surface waters.

A chemical analysis of the cementing material of the present consolidated strata shows it to consist of a mixture of calcium, iron and aluminium salts, together with high percentages of potash and soda (25 to 30 per cent). These bases are combined in a complex manner as chlorides, phosphates, carbonates and sulphates, and were evidently derived from the original feldspathic granites of the Rocky Mountain uplift.

Since the potash lakes are found chiefly in the area covered by the Arikaree formation, and since this formation has been found to contain the highest percentage of potash of any of the Teritary, it is reasonable to attribute tentatively the lake deposits to the potash-bearing Arikaree. This is especially reasonable when it is known that the bulk, or sand (aggregate) of the Arikaree consists of orthoclase feldspars containing from 20 to 35 per cent of potassium in the form of potassium aluminum silicate and the cementing material is a mixture of lime, iron, soda and potash salts containing from 10 to 30 per cent of the latter.

Generally speaking, the lakes of the potash area contain about 40 to 60 per cent total alkali, the better lakes running high in potash (25 to 30 per cent), while the poorer, or alkali lakes, contain from 8 to 15 per cent of potash and 25 to 40 per cent of soda. I believe this variation is best explained by the supposition that the latter lakes represent those which are geologically older, or which are in proximity to some well-defined underground drainage course. It is well known that old topography is characterized by well defined drainage courses.

Since the potash salts are generally the most soluble, they will pass into the ground water more readily than the other salts. Hence we have soda lakes in the eastern portion of the sand-hill area where the drainage is quite mature, and potash lakes in the western part where the concentration is in progress.

The lakes are largely supplied by subsurface drainage from the Arikaree formation still *in situ* to the north and west, and from which there is no apparent outlet for these solutions, owing to the lack of any well defined system of creeks and rivers. There are numerous lakes in the catchment area of both the Platte and the Niobrara rivers, but these are fresh water lakes, since the alkali salts are continuously removed by the natural drainage. Surface potash lakes, on the other hand, exist on the consolidated Arikaree tableland adjacent to Alliance, at a considerable distance from either of these rivers. These later lakes represent the period very early in the life-cycle of a potash lake.

W. A. Norris.

North Platte, Neb.

Electrolytic Pickling of Steel

To the Editor of Metallurgical & Chemical Engineering

SIR:—In your issue of Dec. 15, Prof. M. De Kay Thompson and F. W. Dodson describe some tests which they made comparing electrolytic pickling with chemical pickling. They used black sheet-iron and found that the surface after electrolytic pickling was "much better" and was "a silvery white and very clean" while that treated by the usual chemical process "was not so clean, but was covered with fine black particles which did not wash off easily but which could be removed by rubbing." On this basis they compared the amount of acid and iron in the final solution and then drew their conclusion.

This is on its very face an unfair comparison and misleads those who may be interested in the process, for it is evident that the chemical pickling had not been carried far enough to remove all the scale, and if it had been there would necessarily have been a much greater amount of acid and metallic iron consumed than they found. To "rub" and rewash the iron in large works would increase the cost greatly, but in their academic tests they entirely neglected this important additional cost.

One of the chief advantages of the electrolytic process is that all these deep-seated "black particles" can be dissolved off without dissolving any appreciable metallic iron and without uselessly consuming the corresponding acid. While with the chemical process the most wasteful consumption of metallic iron and the corresponding acid takes place just when these deep-seated "black particles" are being removed, if indeed the process is carried so far, as that leaves the surface deeply pitted. Had they carried the chemical pickling far enough to remove all the oxide to the extent to which it was removed electrolytically or even only approximately, their consumption of metallic iron and acid would have been far greater.

Moreover, in the chemical process they filtered off the scale so that no acid would be consumed in dissolving it. This is academic, as it is not done in practice and would be quite expensive. While the scale is not directly soluble chemically in sulphuric acid, yet when reduced by hydrogen it becomes soluble; and as the agitated liquor is always full of hydrogen considerable of the removed scale in the bottom of the vat no doubt is ultimately dissolved, thereby consuming additional acid quite uselessly, as the object of the pickling had then been accomplished.

Furthermore their acid for chemical pickling was stronger that what I was informed was used in practice, while for the electrolytic process it was weaker than what it should have been; both give undue favor to the chemical process and are therefore unfair and misleading.

That they did not carry out the electrolytic process properly and therefore got wrong and misleading results, is shown by the very low current densities they used, and it was for this reason that the iron was not sufficiently protected by the current and may have been partly dissolved, thereby also uselessly consuming acid. One of the important features about the electrolytic process is that the high current density prescribed protects the clean iron from being dissolved. I have treated a cleaned piece of iron electrolytically at the proper current density about fifteen times as long as it takes to clean it and yet found that it had lost practically nothing in weight, while treated proportionately long by the chemical process the sheets would probably have had actual holes eaten through them. Had they carried out the process as prescribed in the patents they should not have lost an appreciable amount of metallic iron. Moreover, the higher current density would no doubt have also reduced the time required; but even so, when the scale was thick they found it took only 8 minutes as against two and a half hours for the chemical pickling.

In a letter to the writer Professor Thompson states: "I think there probably is very little metallic iron dissolved in the electrolytic method, but we did not determine this." Unfortunately his article gives quite the contrary impression. He adds: "Perhaps it should have been stated (in the article) that no attempt was made to distinguish between the two sources of dissolved iron," meaning whether it had been useful metallic iron or useless scale.

They used the lower current density because they claimed to have found the current "efficiency" to have been greater then. This is academic; the current in the electrolytic process is but a small item of the cost, while the metallic iron lost, with the corresponding acid, is a large item.

The commercial man rightly looks after the dollar; to save a little in a cheap item and thereby lose a lot in an expensive item is not good practice, even though it may appear to be better academically.

It is manifestly not fair to the electrolytic process to conclude from the iron found in solution afterwards that this was originally metallic iron, which is certainly the impression they give when they say that "the amount of iron dissolved was 2.88 grams," or such-and-such per cent of the original oxidized sheet. When properly carried out the iron in solution comes from the scale alone, while in the chemical process it necessarily was nearly all good metallic iron, as they say they filtered off the scale which drops off by dissolving the iron underneath.

Academic tests can be very misleading and deceiving when proper consideration is not given to the factors which are of chief importance in the industrial applications.

Some of the writer's tests were described in METALLURGICAL AND CHEMICAL ENGINEERING for November 1, 1915, p. 785.

CARL HERING.

Philadelphia, Pa.

Permits for Potash Exploration.—Under a recent law permits may be issued for the exploration for potash on tracts of land not to exceed 2560 acres. These permits run for two years, and if potash of commercial quality and quantity is discovered, the permittee will be given a patent for one-fourth of the land covered by his permit, and the remainder may be leased by the Government to others. Secretary of the Interior Lane recently issued the first prospecting permit under this law, covering 2560 acres of alkaline marsh land in the desert region of Inyo County, California, and the permittee expects to promptly begin explorations by sinking wells. Other similar permits will be issued in the near future.

Western Metallurgical and Chemical Field

Canadian Lead Situation

WITH the resumption of operations at the lead smelter of the Consolidated Mining and Smelting Company at Trail, British Columbia, the Canadian lead situation enters upon a new phase. During the early part of 1917 the 12-cent lead market, and the prospect of dollar silver induced miners in British Columbia to extend their production to the utmost. This ore, sent to the smelter at Trail, soon built up a formidable surplus, receipts during the first week in October amounting to the record quantity of 12,600 tons. By this time the lead market had dropped to 7 cents with a prospect of a further decline, the Canadian market was very quiet, and in order to protect itself the smelting company issued a notice stating that lead ores containing more than 4 per cent zinc would no longer be accepted. Since such action would cut off shipments from practically every independent producer in British Columbia—that is to say, in Canada—immediate pressure was brought to bear upon the government to remove the export embargo then existing on lead ores, which the Dominion government decided to do. The greater freight rates to the Tacoma and other smelters in the United States, together with a 6-cent lead market, did not promise much relief to the Canadian miners, however, but meanwhile the Trail smelter announced that after November first it would accept shipments on the basis of the average shipments of the past twelve months. This action on the part of the smelting company was possible following the receipt of a substantial order from the Imperial Munitions Board, which with other orders on their books would assure normal smelting operations until the spring of 1918.

Shipments had hardly been resumed, however, when a very ill-advised and hasty strike shut down the Trail plant for several weeks, again deranging the economic life of the province. On investigation the International Mine, Mill and Smeltermen's Union declared the plant "fair" and censured the local for violating their agreements, whereupon the smeltermen resumed work under their old sliding-scale contracts at lower wages than before the shut down, the price of lead having dropped meanwhile.

Despite these vicissitudes, the production at Trail was 22,130 tons of lead during 1917, which figure is about 2000 tons in excess of that of 1916. Since Canada is making an effort to be self-contained, at least as far as lead is concerned, the possible disposition of this amount of metal within the Dominion is causing considerable discussion. During the preceding years considerable quantities went into munitions, mostly as shrapnel bullets. However, the large Canadian munitions orders early in the war were financed by the Imperial Treasury, as pointed out by Alfred Stansfield in the December bulletin of the Canadian Mining Institute. Since those days Great Britain has been able to increase largely the production of her own factories, and the lack of funds has made it necessary for her to order supplementary material from countries which can loan her enough money to pay for them. Hence the further production of Canadian munitions consuming lead must be financed by Canada herself, and it would require shrapnel worth twenty million dollars to absorb the 10,000 tons of lead annually produced in Canada in excess of her normal peace requirements. Even this material after manufacture may be impossible to ship through the submarine zone, and Prof. Stansfield feels that a more rational outlet for the excess lead is as lead compounds or to replace those lead articles now imported. Before the war Canada consumed annually 30,000 tons as metal and in compounds, while its annual production amounted to but 19,000 tons. While imports of white lead are constantly decreasing, in view of the growth of the Canadian corroding industry, much litharge is still imported and could easily be made locally. The manufacture of sheet lead, lead pipe, and other like products is also a possibility, but only if the Canadian market is assured.

Nebraska Potash Production

As a general proposition it is safe to say that the Nebraska fields have not produced the expected amount of potash during 1917. One plant fell short of its estimates at least 1500 tons due to a variety of causes—labor difficulty, fuel shortage, and the extreme cold weather which cut down the efficiency of the evaporating plants enormously.

The outlook is good for a larger production during 1918, however. Three new plants are in course of construction at Antioch. One owned by the Alliance Potash Company expects to begin operation in May. The other two will doubtless make strenuous efforts to start before the next winter sets in, and they may contribute materially to the total for the year. Building is necessarily slow, owing to the great difficulty in obtaining materials and evaporating equipment. In fact, it is almost impossible for operating concerns to procure certain classes of supplies, such as valves, for instance, and these things are ordinarily rebuilt in their machine shops in order to keep the plants running. Since most of the nearby lakes have been drawn from, the newer plants will face a question of piping the brine long distances.

Shortly after the Government took over the control of the railways extreme difficulty was experienced in getting a supply of oil and coal, but these matters are better adjusted at present, and regular shipments of coal are being received. The oil situation is still causing the operators much uneasiness, the Standard Oil Co. not being able to give assurance about deliveries as to time or quantity. Consequently, fuel oil necessary for the operation of the rotary driers has been shipped from as far as Texas, making the cost almost prohibitory. The labor situation has been better this winter than at any other time since the development of the lakes, cold weather may have an important effect on keeping the floating labor stationary, however.

New Smelter in Arizona

The United Verde Extension Mining Company is constructing a new smelter on a site near the Verde River, about three miles south of Clarkdale, Ariz., where the older plant of the United Verde is situated. The copper ore will be milled to the lowest levels of the mine, which is situated at Jerome, and hauled by standard gage equipment through a haulage tunnel and thence over a private railroad to the smelter bins.

The plant will consist of six roasting furnaces, two reverberatory smelting furnaces, one blast furnace and

three converters. It has been designed with especial attention to future extensions; any part can therefore be enlarged without interfering with the operation of the previously completed portions.

The roasting plant is similar in detail to those now in operation in the most up-to-date smelters in the southwest, the general features of which have already been described by the designer at the Arizona meeting of the American Institute of Mining Engineers.* The furnaces are of the Wedge type, each having its own motor drive.

The reverberatories will be 25 ft. wide and 120 ft. long, and will be fired with pulverized coal. From an improved type of car, the calcines will be dumped into large bins above the firing end of the furnace, from which they will be drawn by scraper conveyors along each side of the furnace, and charged by means of pipes through the furnace roof at intervals of approximately 30 in. along the skewback.

The blast furnace will be 48 in. by 320 in. in size. Coke and ore bins will be placed on either side of the furnace above the charge floor. These bins will be filled by conveyors from supply beds, and will be drawn off into electrically operated charge cars.

The converters will be of the Great Falls type, 12 ft. in diameter, and served by a 40-ton crane. Silica will be charged through conveniently located spouts leading from bins placed above and to the rear of the converters. These bins will be filled with crushed flux by means of suitable belt conveyors.

It had been the intention to start the smelter on April 1, but numerous delays in delivery of material will probably set the date a few weeks later. A. G. McGregor, of Warren, Ariz., is the designer of the plant, and Barry Hogarty is Superintendent for the United Verde Extension Mining Company at the smelter site.

By-Products from Colorado Smelters

In the report of the Colorado Smelter and Ore Sales Investigating Committee, the following statement is made relative to the recovery of by-products at Colorado smelters:

There are two smelting plants in Colorado equipped with baghouses for the recovery of the voltailized material from the blast furnaces. That portion which is volatilized in the roasting of the ore is not recovered at any Colorado plant.

In addition to the recovery of gold, silver and lead from the flue dust and baghouse product, arsenic and cadmium are recovered at the Denver plant. The arsenic plant at Denver treats the flue dust and baghouse product from all company plants. The maximum output of the plant is 120 tons per month of arsenic trioxide.

The cadmium plant at Denver treats the baghouse product supplied from various smelting units of the company, many of which are operating outside the state. The maximum output of this plant is four tons per month.

A small quantity of bismuth was produced from the Leadville plant.

The production of these by-products is the result of the concentration and accumulation of the material treated. With the exception of possible special occurrences, these metals are probably associated with others, and the quantity in the original is so small that the extra expense of its recovery from the crude ores would not be justified, and no accounting is made of their value in the purchase of the ores for the smelters.

Arsenic and bismuth are usually found in combination with sulphur, and cadmium accompanies zinc, and they are all susceptible to high loss from volatilization.

*This journal, Sept 15, 1916, p. 329.

Rapid Growth of American Magnesium Industry

WHEN the European war started, practically all of the magnesium used in this country came from Germany. It soon, however, practically disappeared from the market here and the price soared up to a prohibitive figure so that many manufacturing concerns discontinued its use. It is now being made in this country in comparatively large quantities and the price has now been reduced and is approaching that which was general before the war. It is being sold in small lots for not over $2.00 per pound and in large quantities very considerably below this figure.

According to a preliminary report just issued by Frank L. Hess of the Geological Survey, four American firms were responsible for all the production of magnesium in the United States in 1916—75,400 lb., valued at $311,570. In 1917 five firms produced 115,800 lb., valued at $233,600. In spite of an increase of 65 per cent in quantity there was a decrease of 25 per cent in value, for the average price fell from $4.13 a pound in 1916 to $2.10 a pound in 1917. The price early in 1916 reached $5 a pound. Late in 1917 it fell to $1.85 a pound.

In 1916 magnesium was made by the Electric Reduction Co., Washington, Pa.; Norton Laboratories (Inc.), Lockport, N. Y.; Rumford Metal Co., Rumford, Maine, and General Electric Co., Schenectady, N. Y. The Electric Reduction Co. has found it more profitable to use its power for other purposes, but the other companies named produced magnesium in 1917. The American Magnesium Corporation, the successor of the Aviation Materials Co. at Niagara Falls, made an output in 1917, and the Dow Chemical Co. began production at Midland, Mich., but was prevented from operating at its full capacity by shortage of coal. The General Electric Co., which in 1915 had been forced to make magnesium in order that it might have the metal it needed for its own work, closed its plant in 1917, as the industry is now well established in this country and the price has fallen to a point near that which prevailed before the war.

The Rumford Metal Co. and the American Magnesium Corporation have investigated and produced alloys of magnesium with aluminium, calcium, copper, iron, nickel and silicon. The latter concern is producing an alloy containing 50 per cent magnesium and 50 per cent copper and an alloy containing 20 per cent magnesium and 80 per cent copper. The company has furnished us with the following information concerning these alloys:

"For use as a deoxidizer and scavenger in copper, brass, bronze and phosphor-bronze castings.

Magnesium in small quantities, in copper, brass and bronze castings, has a beneficial effect, making the metal close grained and having superior physical properties. In phosphor-bronze, an excess of magnesium produces pin-

holes and other imperfections in the castings but a small quantity results in much improved metal.

Use a small quantity of magnesium, of about 0.05 per cent, which is amply sufficient for deoxidizing purposes. Probably one-half of this quantity will give even better results in alloys containing zinc, such as brass or bronze, for the reason that there is less oxide to be reduced than in metals like copper or nickel.

Magnesium is, theoretically, a better deoxidizing material than a non-metal like phosphorus. This alloy should be used in copper castings, where high electrical conductivity is desired. It is prepared simply to facilitate its use in the foundry, as magnesium alone is very light and floats and burns on the surface of molten copper and brass unless special precautions are taken to keep it submerged.

One of the principal uses of magnesium is for alloying with aluminium for airplane parts, where lightness is important. By the proper combination of magnesium, aluminium and other metals, in small quantities, an alloy can be produced which will reduce the weight nearly one-half below the weight of No. 12 aluminium. Magnesium is being used more and more as a deoxidizer and scavenger for copper, brass and bronzes and a new alloy of magnesium has been prepared for use as a deoxidizer and scavenger for high grade tool and alloy steels. Another large use of magnesium is in the powdered form for light bombs and flares for lighting night attacks on the European battlefields.

The following references to the use of magnesium have been kindly furnished us by Mr. I. R. Edmands, president of the American Magnesium Corporation:

Brass and Bronze.—An excess of magnesium can be used in deoxidizing without working harm.[1] Usually 0.05 per cent in the case of brass is sufficient. 0.05 per cent increased tensile strength of brass 30 to 50 per cent. 0.05 per cent increased tensile strength of bronze 25 per cent. Elongation increased 40 per cent in both cases.

Copper.—Copper refined in the following way was found equal to the best electrolytic copper.[2] The copper charge is melted in a graphite crucible and the oxides reduced by the addition of 0.1 per cent magnesium in the form of a copper-magnesium alloy containing 20 per cent magnesium. A bi-silicate slag is useful as a solvent for the MgO. Magnesium may be employed for removing the last traces of oxygen from copper that has already been partly refined in the usual way.[3] An excess of magnesium over that necessary to combine with the oxygen must not be used. The copper should be covered by acid slag, or a boric acid flux, with which the MgO will combine. Magnesium is the most satisfactory agent for the deoxidation of copper according to Sperry.[4] The magnesium in the form of bars is alloyed with 90 per cent copper before introducing it into the melt so that it will not float on top. The Mg-Cu ingot is stirred into the metal with a plumbago stirrer. A great advantage of the magnesium is that it decomposes the gases occluded in the melt as well as combining with the oxygen. Thus, CO, which is present in larger proportions than any other gas, is reduced to carbon.

Magnesium-Aluminium Alloys.—An alloy of the following composition has been patented by Chemische Fabrik Griesheim-Elektron:[5] Magnesium 92 per cent; aluminium 8 per cent. Specific gravity 1.75. Strength equal to that of gun metal. The presence of a small quantity of magnesium in aluminium hardens the latter very considerably according to Wilson.[6] Microscopical examination reveals no change in the structure of the metal. The hardening of the metal is accomplished by heating to 500 deg. C., quenching in water and allowing to stand. This hardness develops gradually, as well as an increase in strength and ductility. The metal should not be worked directly after hardening. Heating to 200 deg. C. after this treatment causes a distinct loss of hardness. In the manufacture of magnesium-aluminium alloys according to Klaudy[7] it is of importance that the metals be pure. 10 to 30 per cent magnesium gives an alloy of great strength and easy to work. 2 to 10 per cent produces one that is easy to draw and to roll. Heavy metals can be added to the alloy in such quantity that the resulting density is not greater than that of aluminium. He gives 2 to 5 per cent magnesium as best for wire drawing; 5 to 8 per cent magnesium as best for rolling, and 12 to 15 per cent magnesium as best for casting (pouring). In making alloys of magnesium and aluminium,[8] the aluminium is melted in a graphite crucible and a small amount of cryolite added as a flux. The magnesium is introduced and held beneath the surface with tongs. The average strength of cast 10 per cent magnesium alloy is 20,000 lb. per square inch. Such an alloy possesses an unequaled lightness, the hardness of brass and the strength of cast iron. An alloy recommended for automobile and airplane construction has the following constitution:[9] Aluminium 70 to 90 parts, magnesium 5 to 18 parts, cadmium 2 to 12 parts.

It is most likely that the extent to which magnesium is used will depend on its selling price, and many new uses will undoubtedly be found as the price decreases. We have only to refer to the interesting history of aluminium to obtain an idea as to what is possible with magnesium if it can be produced at a low enough price.

[1] Brass World, 4, p. 226 (1908).
[2] F. Hueser, Metall. u. Erz. 10, p. 473.
[3] Brass World, 9, p. 386 (1913)
[4] E. S. Sperry, Brass World, 1, p. 43 (1905)
[5] U. S. Patent 965,485 (1910).
[6] A. Wilm, Metallurgie, 8, p. 225.
[7] J. K. Klaudy, Ch. Znbl., 1910 (1), p. 245
[8] Brass World, 3, p. 57 (1907)
[9] Brit. Pat. 22,073 (1903).

Status of "Non-Essential" Industries

The Fuel Administration has worked out a plan which provides, in part at least, for necessary restrictions with the least possible injury to industries. This plan provides for fuel curtailment by voluntary agreement among representatives of non-war industries. The effect will be to limit production and make a corresponding saving in transportation and in materials needed for the war. The plan has been tried extensively enough to prove its practicability.

Nevertheless there may be need for more than voluntary co-operation, and for that reason the War Industries Board should immediately list those industries which, as war measures, are of *exceptional importance*. It should determine also, after due notice and hearing, which are the less important industries, measured by the extent of their contribution toward winning the war, and should then announce its findings and enforce plans which will (1) stimulate the operation of industries of exceptional importance, and (2) curtail the operations of the less important, or preferably encourage them to so change their operations as to produce war needs. These are unofficial views of a representative of the War Industries Board.

Platinum Industry Under Government Control

THE production, refining, distribution and use of crude and refined platinum was placed under government control March 1, 1918, for the period of the war. The Council of National Defense has issued a statement on the subject which says that the control will be exercised through the chemical division of the War Industries Board. The chemical division has sent out to the industry requests for inventories of the existing stock of crude and refined platinum and platinum-iridium alloys as of March 1, 1918.

The letter stated that it was not the intention of the government to take over and handle directly the present stock of platinum but to permit its shipment by the producers or dealers subject to certain conditions.

Upon the fixing by the Secretary of War of a reasonable price for crude, refined and alloyed platinum, notice will be given and blanks issued governing delivery and distribution.

The letter sent out by the chemical division includes the following directions to producers:

"1. That producers, refiners and dealers in platinum continue to dispose of their product for government purposes, and for that only, as directed by the chemical division.

"2. That producers, refiners and dealers in platinum who are also consumers use platinum for government purposes, and for that only, as directed by the chemical division.

"3. That all obligations arising out of transactions in the production or delivery of crude, alloyed or refined platinum released as above, including all claims for shortage, poor quality, damage or loss in transit, be borne by the producer or seller, as the case may be, in accordance with existing trade practices.

"Distribution may be made by consent of this board through agencies under existing arrangements, provided that there results no increase over the existing price to the user.

"The undersigned, on separate application in each case, will consider permitting the delivery of a limited amount of platinum for essential commercial purposes not for government account.

"Proper blanks upon which application for release of shipment should be made will be furnished on application.

"The following list indicates, in general, the order of preference which will be followed in releasing platinum for shipment: First, military needs of the United States Government; second, military needs of allied governments; third, essential commercial purposes."

* * *

A supplementary notice sent from the Council of National Defense states that in issuing Ordnance Requisition No. 510, commandeering crude or raw platinum now in the hands of importers or refiners of this precious metal, it is to be understood that this commandeering order does not apply to or interfere with the purchase by the consumer of any manufactured articles containing platinum.

This explanation is made so that the public may clearly understand the purpose of this action by the government.

Water-Power Hearing at Washington

THE week of March 18 will be devoted by the joint water-power committee of Congress to hearings on the provisions of the so-called Administration Water-Power bill. The main features of this bill have been set forth in previous issues of this journal, but are briefly reviewed here together with some amendments which have been suggested by the Secretaries of War, Agriculture and the Interior.

The bill is proposed as a House substitute for Senate bill 1419, known as the Shields bill, which was passed by the Senate in the last Congress. It provides for a Federal Power Commission, for the improvement of navigation and the development of water power. The Commission is empowered to issue licenses

> "for an original period of fifty years, unless a shorter time is agreed upon between the applicant and the commission or is necessary in order that licenses for parts of the same project shall terminate on the same date. Licenses for subsequent periods of such duration and under such conditions as may be prescribed by then existing law and regulations shall be tendered as provided * * * unless and until at the termination of the original, or of any subsequent period, the properties are taken over and compensation made as provided * * *."

An annual charge of not less than 10 cents per horsepower per annum is to be made and paid into the United States treasury. The funds thus accumulated are to be divided for the construction and maintenance of roads in national forests, for the improvement and development of national parks and monuments, maintenance and operation of dams, etc.

The recapture by the government of any projects developed under the terms of the bill may be effected by paying the net investment of the licensee. Net investment is thus defined:

> "'Net investment' in a project means the actual legitimate original cost thereof as defined and interpreted in the 'Classification of investment in road and equipment of steam roads, issue of nineteen hundred and fourteen, Interstate Commerce Commission,' plus similar costs of additions thereto and betterments thereof, minus the sum of the following items properly allocated thereto, if and to the extent that such items have been accumulated during the period of the license from earnings in excess of a fair return on such investment: (a) Unappropriated surplus, (b) aggregate credit balances of current depreciation accounts, and (c) aggregate appropriations of surplus or income held in amortization, sinking fund, or similar reserves, or expended for extensions or betterments. The term 'cost' shall include, in so far as applicable, the elements thereof prescribed in said classification, but shall not include expenditures from funds obtained through donations of States, municipalities, individuals, or others."

If the project is not recaptured by the United States or by a new licensee,

> "the terms and conditions imposed upon the original licensee in any new license tendered shall not be such as to impair the net investment of the licensee in said project or projects."

Intrastate rates and service are to be regulated by state commissions charged with such powers. Interstate rates and service are within the jurisdiction of the federal power commission.

It is understood that the hearing is to be brief and to the point. The general features of water-power legislation have long since been threshed out, and what is now needed is a final agreement on the broad aspects of the bill. Criticism should be confined to constructive comment on the more important factors and should not extend to petty, relatively unimportant details.

Fertilizer Industry Under License

UNDER a proclamation recently issued by President Wilson the importation, manufacture, storage and distribution of fertilizers and fertilizer ingredients are placed under license and are required to obtain license before March 20 in order to continue business. The following commodities are affected: Fertilizers and fertilizer ingredients, including sulphuric acid, phosphate rock, acid phosphate, bones (raw, ground or steamed), bone black, basic slag, sodium nitrate, ammonia sulphate, cottonseed meal, slaughterhouse tankage, garbage tankage, castor pomace, fish scrap, base goods, cyanamid, calcium nitrate, dried blood, acidulated leather, hair, hoof meal, horn dust, ground leather, other unacidulated ammoniates, potash salts, cement dust, blast-furnace dust, kelp ash, kelp char, dried kelp, wood ashes, cottonseed hull ashes, potassium nitrate, tobacco waste, mixed fertilizers, sulphur, and all other fertilizers and fertilizer ingredients.

The order does not apply to companies to which licenses have already been issued under the proclamation of the President of Jan. 3, 1918, relating to ammonia, ammoniacal liquors and ammonium sulphates. The Secretary of Agriculture is empowered to carry the act into effect. Licenses are issued through the Law Department, License Division, U. S. Food Administration, Washington, D. C.

Delaware Chemists Discuss Manufacture of Nitric Acid

The second meeting of the recently formed Delaware Section of the American Chemical Society was held at Hanna's Café in Wilmington on Friday evening, March 8. An address was given by Dr. Edward Hart of Easton, Pa., on the "Manufacture of Nitric Acid." Dr. Hart is director of the Hart Laboratories of Easton and was formerly head of the chemical department of Lafayette College and president of the Baker & Adamson Chemical Co. He is one of the pioneers in the manufacture of nitric acid and originated the Hart condenser, which is used in a modified form in the majority of nitric acid plants here and in other countries except Germany. An abstract of his address will be given in a later issue. Dr. Charles L. Reese, chemical director of the E. I. du Pont de Nemours Co., was present and took part in the discussion. The meeting was presided over by J. E. Egleson, manager of the General Chemical Co.'s plant at Marcus Hook, the chairman, Mr. Lamont du Pont, being unable to attend.

The Delaware Section is an outgrowth of the Delaware Chemists, a former du Pont society, and the Philadelphia Section. It is already very active and has about 150 members. In the district below Philadelphia, on both sides of the Delaware as far as New Castle, it is estimated that there are 500 chemists in the various chemical, explosive, iron and steel and other plants.

Dr. R. P. Calvert of the Experimental Station of the E. I. du Pont de Nemours & Co. is secretary of the section and F. W. Barker of the National Aniline & Chemical Company's plant at Marcus Hook is chairman of the membership committee. The next meeting of the section will be held on the second Friday in April, at which Dr. Charles L. Reese will give an illustrated talk on explosives.

Presentation of Nichols Medal to Dr. Treat B. Johnson

At the regular meeting of the New York section of the American Chemical Society held at the Chemists Club, March 8, the Nichols Medal was presented to Dr. Treat B. Johnson, professor of organic chemistry in the Sheffield Scientific School of Yale University. The award had been made in recognition of Dr. Johnson's contribution to organic chemistry, particularly in the synthesis of pyrimidines.

Dr. Charles H. Herty, chairman of the New York Section opened the meeting with a statement, in part as follows:

> It is a striking fact that in the midst of feverish war preparations, while our minds are filled with death-dealing chemical reactions, we are met together this evening to pay tribute to a quiet worker in the university laboratory, who with infinite patience and consummate skill has accomplished brilliant results in an extremely complex and difficult field of chemical research, that dealing with the fundamental processes of life. I take it as a healthy sign and one presaging great good to chemistry in America that in these days of intense application of science to industrial processes the worker in pure chemistry has been chosen as the recipient of the Nichols Medal.
>
> Under the terms stipulated by its donor, Dr. William H. Nichols, whom happily we have with us to-night in the capacity of leader of the organized chemists of this country, this medal is awarded annually by our Section to the author of the best original article published during the preceding year in the journals of the American Chemical Society. In reaching its decision the committee has construed broadly the conditions of award, realizing fully that in certain lines of research results cannot be withheld indefinitely in order to present in one contribution a comprehensive report of an entire investigation. Such action might lead to loss of priority, and would undoubtedly diminish that stimulative effect which follows the publication of definite chapters in the progress of investigation which in its very nature must require years for completion.
>
> On the basis of such broader interpretation of the terms of award the committee has this year unanimously awarded the medal to Dr. Treat B. Johnson, Professor of Organic Chemistry in the Sheffield Scientific School of Yale University. During the past year Dr. Johnson contributed four articles to the Journal of the American Chemical Society. A fair measure of his activity can be gained from the fact that these four constitute the continuation of a series of one hundred and fifty-four contributions in which his name has appeared as author.
>
> Through this multitudinous array of original communications Dr. Johnson has shown his courage and ability in bringing light into one of the darkest and yet most important fields of chemistry. In reading the advance copy of his address, and noting the brilliant progress he has made through calling the element sulphur to his aid, I am almost forced to describe his activity as devilish. Beginning in 1898, the output of papers from his laboratory has been continuous—two decades of accomplishment to which we all join in paying heartiest tribute.
>
> We are interested to-night, however, not only in the scientific achievements but in the personality of the man whom it is our privilege to honor. Like so many other great Americans, he was born "down on the farm," near Bethany, Conn., on March 29, 1875. In 1898 he graduated from the Sheffield Scientific School with the degree of Ph.B., and three years later received his doctorate from Yale University, having specialized in organic chemistry. A laboratory assistant during his post-graduate course, Dr. Johnson was in 1902 appointed instructor in chemistry in the Sheffield Scientific School. In 1909 he was promoted to an assistant professorship, and in 1914 was advanced to professor of organic chemistry.
>
> It now becomes my pleasant duty to present to you Dr. William H. Nichols, president of the American Chemical Society, who in his life has taken part in many presentations, and who I am sure will sanction the statement that in no similar occasion has he taken greater pleasure than in this.

In presenting the medal Dr. Nichols facetiously remarked that it had been his pleasure to participate in the presentation of a number of medals, but that he had never been the recipient of any. He declared that "it is easier to give than to receive." After paying a general tribute to the chemists of the United States he expressed a willingness to place his reliance in the American chemist in winning the war and establishing American chemical industry on a sound basis. He said that what he had admired most in Dr. Johnson was not the scientific ability displayed nor the brilliance of the research, but the personal quality which had led him to collaborate with others and permit them to share his honors.

Dr. Johnson expressed his appreciation of the honor conferred and read a paper entitled "The Developments of Pyrimidine Chemistry." This paper is of interest primarily to organic research chemists, as it gives a historical review of pyrimidine chemistry for the past 100 years. It has great importance also for the physiological chemist on account of its bearing on the chemistry of life processes. Dr. Johnson divided his review into historical periods beginning with the discovery of alloxan by Brugnatelli in 1917, and closing with the work of himself and associates in discovering new methods of synthesizing uracil, thymine and cytosine.

War Finance Corporation

A BULLETIN issued recently by the National City Bank of New York contains the following comment on the bill for a War Finance Corporation which has just passed the Senate.

It is generally agreed that the time has come for the government to have control over the investment market, with a view to preventing the absorption of capital and labor in enterprises which are now of secondary public importance, and no doubt there is need for the Government to provide special facilities for financing private enterprises which are engaged in war work or business vital to the general welfare. The plan of the War Finance Corporation is well adapted to these ends. It will be provided with a capital of $500,000,000 subscribed by the Government, and it will be authorized to issue its own obligations, running from one to five years, which may be sold to the public and the proceeds used to carry out the purpose in view.

We have had nothing but commendations for this part of the plan, but have deprecated the proposal to admit investment securities sold for the purpose of raising more or less permanent capital as the basis of loans and currency issues by the reserve banks. We have done so because we are sure there is no necessity for such action, and have misgivings that the grant of power will create strong pressure for its use, and tend to divert attention from the policy of general restraint upon private expenditures, which we believe to be the true one for this time.

So far as protection of savings banks is concerned we have stated that provision to pay their depositors, if there is any occasion for so doing, is not open to the objection raised against supplying money for industry, for if depositors want their money for the purpose of buying Government bonds all payments to them will come into the Treasury and can be returned to the reserve banks as deposits. It is only as loans are made in attempts to enlarge the volume of industry, at a time when by reason of natural limitations, it cannot be enlarged, that inflation occurs. Likewise, refunding operations make no demands upon labor or new capital, and, therefore, do not require resort to the reserve banks.

With a close control over the investment market to restrict the employment of capital to approved undertakings, there is no reason to doubt that there will be plenty of capital to meet the important demands contemplated in the bill. At any rate it is certain that no capital can be created by borrowing of the reserve banks at a time when the working forces of the country are already employed to the limit. The point has been reached then when the relief must come by another method—the method referred to by a member of the Federal Reserve Board in a recent address, as follows:

> The question which I believe, in view of this situation, the country must soon face, is whether it will be the part of financial prudence for us to attempt to finance our Government loans by an expansion of banking credit with accompanying inflation of prices, or whether it will be better, however drastic the steps necessary to accomplish this result may be, to pursue the course of converting the potential savings fund of the nation into an actual savings fund of sufficient magnitude to absorb the loans of the Government as *savings loans*.*

The pending bill seems likely to become a law without important changes, and will doubtless be administered with great discretion. Our attitude toward the questionable feature has been prompted by apprehension that the public would interpret the measure as providing for expansion, and proceed to manage its private affairs in such a manner that the authorities might be compelled finally by resulting conditions to use the new powers to a degree not contemplated at the outset.

The interpretation which at least a portion of the public places upon the measure was stated by the market reporter of the *Wall Street Journal* after it had been reported to the Senate, as follows:

> The economist who argued that eggs now selling at 60 cents a dozen would sell at $1.50 when the War Finance Bill became a law gave an illustration which the public understands. He may not be exactly right on figures, but the financial district sides with him in his argument. It follows that with commodity prices higher many other things which money can buy, stocks included, may sell higher.

This cheerful view is not confined to the stock market, and probably there are more who hold it than there are who understand that to whatever extent the act has influence upon industrial conditions it will increase the cost of the war and the amount which the Government must raise by taxation and loans.

Coming Meetings and Events

Dyestuff Association of America, Rumford Hall, Chemists' Club, New York, March 6.

American Electrochemical Society, Spring meeting, Southern trip, week of April 28.

American Society of Mechanical Engineers, Worcester, Mass., June 4-7.

American Institute of Chemical Engineers, Berlin, N. H., June 19-22.

American Society for Testing Materials, Atlantic City, June 25-28.

*Address of Dr. A. C. Miller before the American Academy of Political Science, Philadelphia, November, 1917.

Dyestuff Manufacturers Perfect Organization

THE American dyestuff industry was formally organized on March 6 at a meeting held at the Chemists' Club in New York. The chief feature of the meeting was the decision of those present to limit the organization exclusively to American manufacturers of dyestuffs and intermediates. A firm stand on this point was taken by a large majority of the principal manufacturers.

The report of the organization committee, appointed at the preliminary meeting on Jan. 22 was presented by Dr. J. Merritt Matthews, the chairman of the committee. He said the various members of the committee had ascertained from as large a number as possible just what kind of an organization would best serve the interests of our dyestuff industry. The committee after carefully considering the matter then adopted a resolution that an organization be formed to be known as the Dyestuffs Manufacturers' Association of America or some similar name, to consist of manufacturers of dyes and intermediates, and that the dealers form a separate organization, if they so desire.

After the recommendations of the organization committee were presented, a lively discussion took place for and against the inclusion of dealers in the association. Mr. H. G. McKerrow, the originator of the organization and a member of the organization committee, presented a minority report of that committee outlining a plan of organization in which there would be three sections, manufacturers, dealers and allied interests. He was very strongly in favor of including all interests.

When it came to a vote on the subject it was seen that practically all of the manufacturers were in favor of an exclusive organization, and a motion was carried that such an organization be formed. There were not more than half a dozen dealers present and about twenty-seven manufacturers. There were also present quite a large number of representatives of allied interests.

The chief points in favor of an exclusive manufacturers' association were, (1) that dealers' interests will not be essentially American after the war, as they will buy wherever they can; (2) that it has been the experience of other associations that the best results are accomplished by separate organizations connected only through their councils, and (3) that most of the manufacturers are averse to having the dealers included.

The chief points in favor of a mixed organization brought out were, (1) that no sharp line of demarcation could be drawn between manufacturer and dealer as many were both; (2) that small manufacturers are dependent on dealers to market their product, and (3) that dealers are apt to work against the best interests of the American industry unless included as a part of the industry.

The following board of governors was elected to formulate by-laws, nominate officers and take up the other problems, such as the tariff, standardization, etc.: G. H. Whaley, John Campbell & Co.; Dr. Poucher, E. I. du Pont de Nemours & Co.; Alfred Blum, United Piece Dye Works; Mr. Jeffratt, Calco Chemical Co.; August Merz, Heller & Merz; Mr. Orth, Marden, Orth & Hastings Corp.; Frank Hemingway, Frank Hemingway, Inc.; L. A. Ault, Ault & Wiborg Co.; J. M. Matthews, Grasselli Chemical Co.; Mr. Cottingham, Sherwin-Williams Co.; Robt. Kemp, Read-Holliday & Co.; R. P. Dicks, Dicks, David & Co.; I. V. Stanislaus, Stanley Aniline & Chemical Co.; E. H. Killhefer, Newport Chemical Works.

What the Tariff Commission Is Doing

The following subjects included in the chemical schedule have been undertaken for study by the Tariff Commission and co-ordinated reports of all available information are under way for the use of Congress. Well advanced and subject to early promulgation are: dyes and coal-tar products, sulphur and sulphuric acid, barium compounds, bleaching powder and other chlorine products, citric and oxalic acids, and botanical drugs. In earlier stages of preparation are: lactic acid, thorium nitrate, potash, wood distillation and its products, soap, glycerine and fatty oils, and paints and pigments. Other subjects will follow.

The first study was made on dyes and coal-tar products and this has now progressed so far that it is probable that the first official memorandum on a chemical group of products will be forthcoming within a few weeks' time. We shall reserve discussion until the complete report appears.

A great deal of information has to be asked for because changes are far too rapid to depend upon the U. S. Census; but by friendly co-operation with other departments of the Government much timely information is obtained and the work advanced. A very important report that is in preparation for the benefit of Congress is on the significant changes in chemical industry that have come about owing to the war, with especial reference to changes likely to have a permanent influence on international competition. Work along similar lines is in progress on the metal schedule.

It is hoped that manufacturers and merchants will present their appeals for aid or relief to the commission rather than attempt to spring undigested claims upon Congress at the last moment of debate. The temper of the national legislative body under its great pressure of work is such that neglect to inform the proper authorities of facts bearing upon tariff laws is likely to meet with impatience. Clever dodges are growing exceedingly unpopular.

Native Chinese Industries Discussed at Joint Chemical Meeting

At a joint meeting of the New York Sections of the American Electrochemical Society, American Chemical Society and Society of Chemical Industry held on March 1, two illustrated lectures were given on the native industries of China. Mr. H. K. Richardson, who spent four years in West China in charge of a Y. M. C. A. industrial school, described the production of placer gold, coal briquets, salt, matches, glass, indigo, sugar and tung oil. Mr. C. N. Laird of the Canton Christian College, South China, discussed and showed the primitive processes of making peanut oil and clay products.

Nitric Acid and Copper Ore

By GEORGE C. WESTBY

THE treatment of ores with nitric acid is not commonly resorted to even by the most daring of metallurgists. Occasionally, however, the exigencies of a situation cause the most cautious to look outside the boundaries of established practice, and sometimes a nitric acid process has seemed alluring.

Very little has been published in connection with the quest of those who have departed from the beaten metallurgical track, and sought to utilize nitric acid in ore treatment. This is the story of perhaps one attempt out of many unrecorded ones.

The force of circumstances, the nature of which it is needless to consider, induced an enterprising mining company to give the inventor of one of the nitric acid ore processes an opportunity to demonstrate the commercial value of the process.

Briefly, the method consists in a regulated addition of a batch of ground sulphide ore to warm, dilute nitric acid contained in a Pachuca-shaped vessel, called a digester. The heat developed by the ensuing reaction brings the temperature of the mixture up to around 100 deg. Cent. Steam is admitted to maintain the temperature between 80 deg. and 100 deg. Cent. as the chemical action in the digester gradually fails in energy with the weakening acid.

Compressed air admitted at the bottom of the digester agitates the mixture, and also supplies the oxygen necessary for the oxidation of the nitric oxide, which is developed by the action of the acid on the ore, to nitrogen peroxide.

The nitrogen peroxide produced in the digester together with the excess air is forced through a series of quartz-charged absorption towers partly filled with water. This results in the conversion of the nitrogen peroxide to nitric acid, which is again available for the treatment of fresh ore.

Disappearance of the colored nitrogen peroxide from the gases passing to the absorption towers as shown by a glass lantern inserted in the pipe line connecting the digester with the absorption system, marks the practical completion of the action of the acid on the ore. The contents of the digester are then discharged to the washing and filtering system.

Chemistry of the Process

The rationale of the process so far as it applies to the treatment of cupriferous pyritic ores is conveniently summarized in the following equations:

$$2FeS_2 + 10HNO_3 = Fe_2(SO_4)_3 + H_2SO_4 + 4H_2O + 10NO \quad (1)$$

$$3CuS + 8HNO_3 = 3CuSO_4 + 8NO + 4H_2O \quad (2)$$

$$6CuFeS_2 + 46HNO_3 = 6Cu(NO_3)_2 + 3Fe_2(SO_4)_3 + 3H_2SO_4 + 20H_2O + 34NO \quad (3)$$

$$6Cu(NO_3)_2 + 6H_2SO_4 = 6CuSO_4 + 12HNO_3 \quad (4)$$

$$6CuFeS_2 + 34HNO_3 + 3H_2SO_4 = 3Fe_2(SO_4)_3 + 20H_2O + 34NO + 6CuSO_4 \quad (3 \text{ \& } 4)$$

$$4NO + 2H_2O + 3O_2 \text{ (air)} = 4HNO_3 \quad (5)$$

$$4NO + O_2 = 2N_2O \quad (6)$$

$$N_2O_3 + H_2O = 2HNO_2 \quad (7)$$

$$3HNO_2 = HNO_3 + 2NO + H_2O, \text{ also} \quad (8)$$

$$2HNO_2 + N_2O_4 = HNO_3 + 2NO \quad (9)$$

$$2NO + O_2 = 2NO_2 \quad (10)$$

$$2NO_2 + H_2O = HNO_2 \quad (11)$$

The hypothesis is sometimes advanced that under the conditions of the treatment described it is not necessary to add as large a proportion of nitric acid to the ore as the quantity called for by the terms of equations (1), (2) and (3). The postulate is based on the inference that nitric acid would be largely regenerated within the digester, as the liberated nitric oxide mixes with the air and liquid spume in the space above the reacting ore and acid. It will be seen, however, from results of experiments given below, that this regeneration is insufficient to produce marked effects in extraction of further valuable metal from the ore.

Also with reference to equations (1), (2) and (3), we have illustrated the fact that the material subjected to treatment is preferably a sulphide ore containing sufficient combined sulphur to permit the formation of sulphate from all bases susceptible to attack. Excess of sulphur might be taken up by the addition of an oxidized ore, a deficiency must be remedied by the introduction of sulphuric acid or its equivalent.

Further, in connection with formulæ (1) and (2), the statement might be made that successful commercial application of this form of nitric acid process hinges largely on virtually complete evolution of sulphates in the reaction of nitric acid on the sulphides, for production of nitrates in appreciable quantities involves ultimate loss of this expensive reagent in the discharged tailings and in the solutions discarded from the precipitation system of the plant. An expression for a possible subsidiary reaction occurring simultaneously with equation (1) is

$$8HNO_3 + 2FeS_2 = 2Fe(NO_3)_3 + 2NO + 4H_2O + 2S_2 \quad (12)$$

Equations (4) to (9) inclusive refer especially to means of regenerating nitric acid from nitric oxide, air and water, and indicate the circuitous path traversed by a portion of the nitrogen compounds in the formation of nitric acid.

In the absorption treatment it is necessary to keep the cooled nitrose gases in contact with the water and air for at least five minutes, and this implies careful proportioning of the absorption system to the volume of gases we expect to treat. German and English practice has shown that when an adequately large mixing and tower system is provided, practically complete absorption with corresponding recovery of nitric acid is possible; however, even with the use of an end tower charged with an alkaline liquor, it is seldom commercially feasible to obtain a greater absorption than 97 per cent of the nitrose gases passing through the system. The commercial meaning of a 3 per cent loss of nitric acid in a regenerative process using nitric

acid as a solvent for cupriferous pyritic ores, is painfully apparent in estimates submitted in connection with the results of tests given farther on in this record.

Experimental Work with Laboratory Apparatus

Preliminary tests on the process outlined were made with a glass apparatus designed to treat two or three pounds at a charge. The apparatus consisted of the parts represented in Fig. 1. *A* is a closed ore-holder provided with a removable top through which ore may be introduced. The digester *B* is situated directly under the holder and the two parts are connected by a short conduit, in which the feeder controlling the flow of ore to the digester operates. Steam and air pipes connected with the bottom of the digester provide means for heating, agitating and oxidizing the mixture charged to the digester. The nitrose gases formed in the digester escape through the exit pipe, the cooling coil and lanterns *C* and *D* to the mixer and condenser *E*, thence, by the pressure formed within the digester

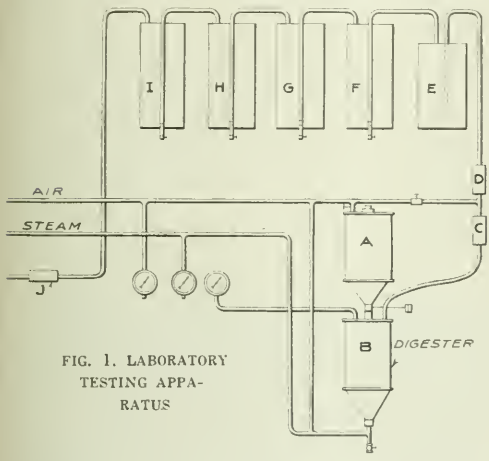


FIG. 1. LABORATORY TESTING APPARATUS

the gases are forced through the absorption towers *F*, *G*, *H* and *I* to the final discharge. As shown by sketch, an air-pipe connection is made between lanterns *B* and *D*. This arrangement provides a means for testing the completeness of the oxidation of NO to NO_2 by comparison of the depth of color when air is turned into the gas stream passing through the lanterns. The gages shown register air, steam and digester pressures.

Many of the results obtained from tests were vitiated by leaks which developed in most unexpected places as the pressure in the apparatus approached 10 lb. gage per square inch; but the tests submitted, in order to illustrate the general possibilities of the process, were selected because no leaks were detected after close inspection of the apparatus throughout the test.

Test No. 1

Analysis of Ore

	Per Cent
Al_2O_3	2.0
S	29.0
CaO	5.8
Cu	3.6
Fe	26.9
Insol	26.4

The gangue was garnetiferous with calcite present.

Estimation of acid required to treat the ore is based on equations (1), (2), (3) and (4), and consideration of sulphur (or equivalent sulphuric acid) required to sulphatize all the basic elements of the ore.

Assuming all copper in the ore and part of the iron combined with sulphur to form chalcopyrite ($CuFeS_2$), we have by equations (3) and (4) the factors Cu, Fe, S, HNO_3 and H_2SO_4 expressed in the ratios

$$378 : 336 : 384 : 2142 : 294$$

respectively, which gives when represented in per cent referred to the analysis and weight of the ore

Cu 3.6%, Fe 3.2%, S 3.65%, HNO_3 20.4% and H_2SO_4 2.8%.

Considering the balance of the sulphur combined with iron to form FeS_2, we obtain from the ratios derived from (1) the following expressed in terms of per cent referred to the analysis and weight of the ore:

Fe = (26.9 — 3.2 — 1.52) = 22.18%
S = (29.0 — 3.65) = 25.35%
HNO_3 = 124.53%
H_2SO_4 = 19.4%

Consequently we require (20.4 + 124.53) = 144.93% of absolute nitric acid as referred to the total weight of ore to be treated, to decompose the sulphide constituents in accordance with the equations given. Further, assuming the basic constituents of the gangue, such as iron, alumina and lime, to be readily susceptible to the action of the dilute sulphuric acid of the solution, we require for

1.5% Fe	a quantity of H_2SO_4 equivalent to	3.9% of wt. of ore
2.0% Al_2O_3	a quantity of H_2SO_4 equivalent to	5.7% of wt. of ore
5.8% CaO	a quantity of H_2SO_4 equivalent to	10.2% of wt. of ore
Total		19.8%

Finally then, considering all sulphur shown in the left hand member of the equations discussed, oxidized to sulphuric acid, we require for treatment of

$CuFeS_2$	a quantity of H_2SO_4 equivalent to	13.97% of wt. of ore
FeS_2	a quantity of H_2SO_4 equivalent to	58.18% of wt. of ore
Gangue	a quantity of H_2SO_4 equivalent to	19.80% of wt. of ore

or for sulphatizing all bases equivalent to 91.95% of wt. of ore

The total sulphur present as sulphide in the ore, oxidized to H_2SO_4 would yield a quantity of H_2SO_4 equivalent to 88.74% of the weight of the ore. Consequently we must add 91.95 — 88.74 = 3.2% of weight of ore of H_2SO_4 to complete the sulphatizing of the bases mentioned.

While it is evident that a slight excess of sulphuric acid also might be very useful in completing the dissolution of the ore and accelerating the extraction of the valuable metals, no H_2SO_4 was added in the preliminary tests in excess of that called for by the estimate derived in the manner given above.

In the test under discussion 554 grams of ore was charged to the digester. In accordance with the estimate outlined there should be added 788 grams HNO_3

and 17.73 grams H_2SO_4. However, only 1500 cc. of 1.24 sp. g. nitric acid was added containing 707 grams HNO_3. This was to insure maximum regeneration of nitric acid charged to the digester in order to determine the practical effect of possible regeneration within the digester and to neutralize the nitric acid.

General conditions during the test were as follows:

Feeding ore to digester, min.	60
Length of run, min.	94
Gage pressure at start, lb.	8
Gage pressure finish, lb.	10
Average temperature of mixture in digester, °C	64.6
Highest temperature of mixture in digester, °C	77
Lowest temperature of mixture in digester, °C	40
Temperature at finish, °C	56

Nitric acid recovery.	HNO_3 g
In absorption towers	484
In mixer or condenser	185
	669
Nitric acid losses.	
In solution discharged	41
Lost by discharge from absorption towers by difference	7
	48

	Per Cent of Original
Therefore available recovered acid was	93.4
Acid regenerated in absorption system	67.5
Equivalent HNO_3 in solution discharged	5.7
Equivalent HNO_3 lost as nitrose gases	0.9
Cu extraction (allowing for Cu in excess ore)	87.3

TEST NO. 2

Analysis of Ore

Al_2O_3	2.0
CaO	8.5
Fe	29.0
S	32.2
Cu	5.1
Insol	21.7

Expressed in terms of percentage referred to the weight of ore, sulphatizing of the bases requires for

	Per Cent S
Copper to form $CuSO_4$	2.6
Iron to form $Fe_2(SO_4)_3$	24.8
Lime to form $CaSO_4$	4.9
Alumina to form $Al_2(SO_4)_3$	1.9
Representing a total of	34.2

Sulphur supplied by ore is 33.2%. Sulphur deficiency to be supplied in the form of H_2SO_4 is accordingly 2.0%, equivalent to 6.1% H_2SO_4.

Based on equations (1), (3) and (4) approximately 161% HNO_3 is called for in the treatment of the ore.

	Grams
Weight of HNO_3 in 1500 cc. 1.26 sp. gr. acid charged to digester	782
Weight of ore charged	750
Giving an excess of	285

General conditions during the test were as follows:

Feeding 80-mesh ore, min.	44
Length of run, min.	70
Gage pressure, at start, lb.	6
Gage pressure, at finish, lb.	10
Average temperature of mixture in digester, °C	75
Highest temperature of mixture in digester, °C	87
Lowest temperature of mixture in digester, °C	40
Temperature at finish, °C	83

Nitric acid recovery.	HNO_3 g
In absorption towers	509
In mixer or condenser	187
Total	696
Nitric acid losses.	
In solution discharged	51
Lost in discharge from end absorption tower (by dif.)	35
Total	86

	Per Cent of Original
Therefore available recovered acid was	89.0
Equivalent HNO_3 in solution discharged	6.5
HNO_3 lost as nitrose gases	4.5
Copper extraction from ore	89.5

If the equations tentatively given as an expression of processes of this type are substantially correct, we should expect fairly close accordance between the figure representing the percentage recovery of nitric acid and that giving per cent of bases dissolved. It was found that a relationship existed even in tests where an excess of nitric acid was used, that tended to establish the fact that the treatment progresses in general accordance with equations (1), (3) and (4), and that the reaction expressed by (12) is not an important factor in the process.

The results of ten tests gave:

	Per Cent
Average nitric acid recovery	90.5
Average copper extraction	88.9

Some distillation of HNO_3 from the solution is indicated, but the acid brought into the absorption system by distillation cannot be of consequence, since the acid added to the digest is dilute and constantly decreasing in strength as the reaction of the acid on the sulphides proceeds.

In one or two tests excessive agitation projected a larger quantity of undecomposed acid into the condenser. The results of the second test given above are an example of this condition. An appreciable regeneration of nitric acid within the digester should become apparent by relative increase of the figure expressing the percentage of extraction of bases over that showing the recovery of nitric acid, but eliminating ques-

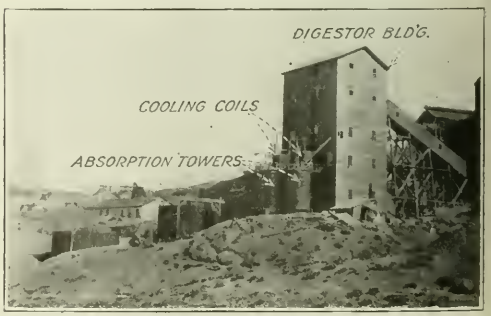


FIG. 2. EXPERIMENTAL UNIT FOR NITRIC ACID PROCESS

tionable results, in no test of the series did the results show a higher figure for extraction of base than that expressing acid recovery. It is conceivable that distillation and regeneration of acid might balance, but in view of the fact that the conditions in the digester do not coincide with the conditions necessary for effective absorption of NO_2 as given above, and the further fact that the distillation is necessarily small, there is reason for the conviction that regeneration in the digester is inconsiderable.

Comparative Cost of Nitric Acid and Leaching Processes

Before proceeding with a résumé of results obtained from the application of the process on what was expected to be a fifty-ton scale, we submit comparative estimate of cost between the nitric acid process and one in which roasting and sulphuric acid leaching are the main features of the treatment.

It will be noted that a high recovery of nitric acid is assumed, for it will be seen that a high recovery of acid is necessary if the process is to be considered at all as a commercially feasible proposition.

The cost given for air may seem high, but it is based on actual measurements of the air used in some of the tests and consideration of the air theoretically required as shown by equations (1) and (10).

We have from equation (1) the ratio:

$$2FeS_2 : 10NO = 240 : 300 = 1 : 1.25$$

Under standard conditions the weight of one cubic foot of NO is 0.082 lb. (nearly).

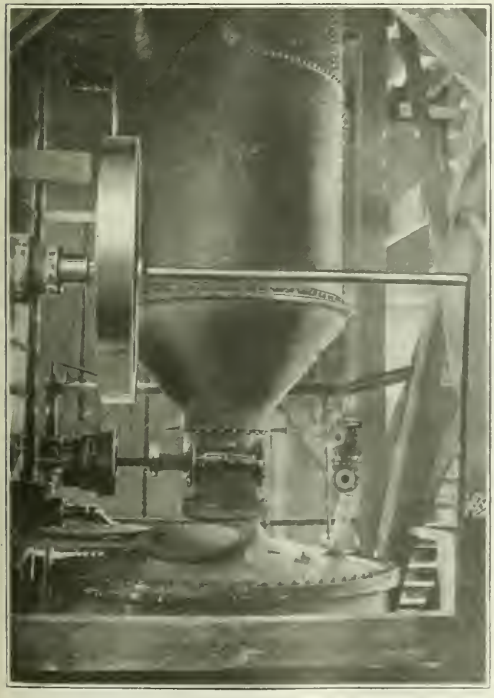


FIG. 3. LOWER SECTION OF ORE-HOLDER, FEEDER DRIVE AND TOP OF DIGESTER

$$\text{Then } \frac{1.25}{.082} = 15.24$$

Consequently in theory 1 lb. of FeS_2 develops with HNO_3 15.24 cu. ft. of NO, or at 68 deg. F. (20 deg. C.) and 24 in. barometric pressure, 19.62 cu. ft. NO.

From equation (10) 1 lb. of NO theoretically requires 0.532 lb. of oxygen in forming NO_2, calling for 2.32 lb. of air, or 48.2 cu. ft. of air at 68 deg. F. and 24 in. barometric pressure.

To compress and deliver 48.2 cu. ft. of air per minute at 30 lb. pressure requires about 4.1 hp., which is explanatory of the cost item for air.

Data assumed in consideration of nitric acid ore treatment.

HNO_3 manufactured at the mine at 3c. per lb.

Loss of HNO_3 = 2% of total added.

Copper recovery = 90%.

	Per Cent.
Ore assay, Cu	3.6 = 72 lb. Cu per ton
CaO	5.8
Fe	26.9
Insol	26.4
S	29.0
Al_2O_3	2.0

Estimated cost of treating one ton of ore by HNO_3 under conditions assumed:

Mining 1 ton of ore	$1.25
HNO_3 2% loss at 3c. (58 lb. at 3c.)	1.74
H_2SO_4 to correct sulphur deficiency (64 lb. at ½c.)	.32
Amortization and interest on plant	.30
Crushing and grinding	.60
Filtration and washing	.10
Air and steam	.50
Labor about digester	.50
Precipitation of copper	.65
Freight, selling, etc. (65 lb. Cu at 2c.)	1.30
	$7.26
Credit 64.8 lb. Cu at 15c	9.72
Possible net	$2.46

Data assumed in consideration of treatment by sulphatizing roast followed by H_2SO_4 leaching.

Analysis of ore—given in preceding estimate.

Leaching in tanks by percolation.

Copper recovery, 90%.

Estimated cost of treating one ton of ore by roasting and leaching:

Mining one ton of ore	$1.25
Roasting	1.00
H_2SO_4 required—300 lb. at ½c	1.50
Amortization and interest	.35
Crushing and grinding	.35
Handling tailings, pumping, etc	.05
Precipitation of copper	.65
Freight, selling, etc. (65 lb. Cu at 2c)	1.30
	$6.45
Credit 64.8 lb. Cu at 15c	9.72
Possible net	$3.27

The results of the laboratory tests of the nitric acid process were instructive, but unfortunately did not emphatically prove that the process was a striking improvement on methods of ore treatment which it was

designed to supplant. The promoters of the process, however, were of the opinion that the laboratory-scale tests proved nothing of what might be done with larger apparatus. They mentioned achievements in different fields with a large digester, stating also that a 40 per cent regeneration was a common experience with the special type they had worked with; moreover, they owned a complete 50-ton plant ready for installation. The mining company determined to allow the process company to proceed with the erection of their commercial unit.

Supplementary Test on Large Scale

The plant was made an adjunct of a dry-crushing mill and was similar in general arrangement to the small laboratory equipment already described. The digester was about 7 feet interior diameter and 14 feet high, and was lined with acid-proof brick set in acid-proof cement. The ore-holder was made of heavy sheet iron and was approximately 12 feet high and 7 feet in diameter. The condensation and absorption system consisted of two 3-in. aluminium coils made up with about 240 feet of pipe, and set in tanks supplied with circulating water; a condenser made from a lined sheet-iron cylinder placed inside a high wooden tank, through which cold water circulated; and a set of five absorption towers, four of which were 16 feet high and about 7 feet in diameter and the fifth in the series 16 feet high and 10 feet in diameter. Pipe connections were made with 2½-in. and 3-in. aluminium pipe and fittings. Solution pipes and fittings were made of duriron. The 1½-in. solution pump used was also made of that alloy.

In operation sulphide ore from the mill was diverted from a conveyor to a small bin situated above the ore-holder. Weighed batches of ore were drawn for each test from the bin to the ore-holder. Nitric acid or a mixture which might consist of a solution of nitric acid, sulphuric acid and nitre was run into the digester from a measuring tank. The solution was then heated by means of steam, which passed into the bottom of the digester through a rubber hose and duriron connections. After the solution had attained a temperature approaching 140 deg. Fahr. air was forced into the digester with the steam and the ore-feeder started.

In presenting the subjoined data it should be stated that the nitric acid was for the most part not added directly to the ore, but was developed indirectly in the solution in the presence of the sulphide ore by means of nitric and sulphuric acid. This method, however, was stated in the patent specifications to be equivalent to the use of nitric acid.

Two of the most successful tests are selected for illustration. The tests were controlled and carried out by patentees of the particular nitric acid process used, the company's representatives making duplicate tests at the same time.

Test A

Ore Analysis.	Per Cent.	*Screen Analysis.* Mesh.	Per Cent.
Cu	2.15	+ 14	0.41
S	16.30	+ 20	6.20
Fe	14.7	+ 30	23.03
Insol	50.4	+ 40	14.80
CaO	5.8	+ 80	23.75
Al_2O_3	5.9	— 80	32.13

General Conditions: Solution heated 40 minutes in digester with steam at 60 lb. pressure. Period feeding ore 143 minutes, the ore being charged intermittently.

Total period of treatment, hr.	5
Ore charged to holder, lb.	4229
Ore left in holder, lb.	980
Actual ore charged to digester, lb.	3249
Ore in excess as figured from HNO_3 added, lb.	1080
Nitric and sulphuric acids charged to digester:	
Per cent HNO_3 in solution	12.8
Weight of acid solution, lb.	13,860
Specific gravity	1.26
Weight of HNO_3 in solution, lb.	1774
Weight of H_2SO_4 added, lb.	2217
Weight of H_2SO_4 used for decomposing nitre, lb.	1556[1]
Weight of H_2SO_4 available for bases, lb.	661
Temperature of solution added to digester, °F.	90
(Solution was later further heated in digester.)	
Nitric and sulphuric acid required to treat charge:	
Approximate weight of HNO required, based on assumption of complete neutralization of acid by 3249 lb. of ore, in accordance with equations (1), (2), (3) and (4), lb.	2657
Weight of HNO actually added, lb.	1774
Deficiency of HNO implying excess ore, lb.	883
Sulphuric acid required for bases, lb.	2174
Sulphuric acid supplied by ore (as S), lb.	1625
Sulphuric acid to be added, lb.	549
Sulphuric acid available in solution charged to digester, lb.	661
Sulphuric acid excess, lb.	112

[1]Some free HNO_3 from absorption tower used in these tests.

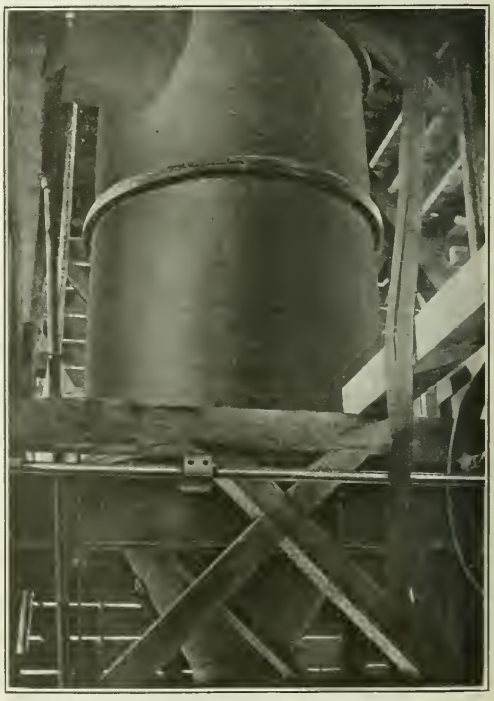


FIG. 4. LOWER PART OF DIGESTER

Nitric acid recovery and losses:

Nitric acid added to digester, lb.	1774
Nitric acid recovered in towers and condenser, lb.	1301
Nitric acid remaining in discharged solution, lb..	437
Nitric acid lost from end tower in form of nitrose gases, lb.	43
Percentage nitric acid recovered from towers and condensers	73.2
Percentage nitric acid in digester discharge	24.3
Percentage nitric acid loss through end towers in form of nitrose gases (by dif.)	2.4

Tailings Analysis:

	Per Cent.
Cu	1.29
Fe	7.8
CaO	3.9
Al_2O_3	4.9
S	7.7
Insol	69.7

Ratio of pulp to solution by weight 1.63.

Extractions:

	Per Cent.
Copper	67.2
Iron	71.4
Sulphur	67.4

Nitric acid recovery in towers plus loss through end 75.7 per cent.

Remarks:

The probability is strong that the difference between 75.7 and 67.4, figures representing total acid driven from digester and sulphur dissolved respectively, is an approximate measure of the quantity of nitric acid either distilled or mechanically carried into the absorption system.

The strength of the discharged solution in HNO was approximately 3 per cent. Action of this dilute solution on the excess sulphide present would doubtless continue, but the action is undoubtedly slow and there is more than a possibility that nitrogen compound such as N_2O may be formed in a large degree, as the acid weakens with sulphides in relative excess; these compounds would not be recovered in the absorption system.

TEST B

Ore Analysis

	Per Cent.
Cu	2.15
S	15.3
Insol	46.5
CaO	7.6
Al_2O_3	5.3
Fe	15.5

Ore Charge:

Ore charged to holder, lb.	3881
Ore left in at end of test, lb.	2271
Actual charge of digester, lb	1610

Note: Dry weights are given.

Nitric and sulphuric acids:

HNO added to digester, lb.	1735
HNO theoretically required (approx.), lb.	1231.5
Excess, lb.	503.5
Sulphuric acid charged, lb.	1400
Sulphuric acid required for bases and decomposition of NaNO	1372

Nitric acid recovery:

Recovered in towers, lb.	634.1
Recovered in condensers, lb.	93.1
Recovered, total, lb	727.2
Percentage recovery of HNO based on theoretical HNO_3 required	59.1
Percentage recovery of HNO plus end loss through absorption towers	62.46

Nitric acid losses:

Nitric acid in digester at finish as nitrates and free HNO_3, lb.	966.6
Nitric acid in excess of theoretical required, lb.	503.5
Nitric acid figured for treatment of unchanged sulphides, lb.	463.1
Nitric acid lost through end absorption tower discharge as nitrose gases, lb.	41.4
Percentage nitric acid lost through end absorption tower discharge as nitrose gases	3.36
Percentage nitric acid left in digester (of theoretical)	37.54

Discharged Solution:

Weight, 10,174 lb.

Cu = 0.24 per cent = 24.4 lb.

Fe = 1.72 per cent 175.0 lb.

S = 6.0 per cent = 610.0 lb. 610

457.2*

152.8 lb. sulphur derived from ore.

HNO = 9.60 per cent 19 lb. S approx. left in tailings in combination as $CaSO_4$

Contents of Original Ore

34.62 lb. Cu

246.33 lb. S

249.55 lb. Fe

From these results we obtain the subjoined figures:

Extractions:

	Per Cent
Cu	70.5
Fe	70.1
S	69.8
HNO	62.4 passing into absorption towers and condenser

Tailing Analysis:

Per Cent		
Cu	1.74	10.22 lb. by diff. which gives 587 lb. tails
Fe	13.3	74.55 lb. by diff. which gives 560 lb. tails
Insol	55.8	
CaO	5.2	
S	14.2	93.5 lb.

3.0 of above combined with CaO

The fact that the figure for extraction of bases is numerically greater than that for nitric acid recoveries (plus the fumes passing through end tower) gives reason for the belief that in this case some copper and iron are in the form of nitrates. And we may suspect the operation of a reaction as expressed by equation (12).

Temperature:

The temperature of the gases passing from the digester varied during active operation between 177 deg.

*Note 457.2 lb. S [illegible] H_2SO_4 to digester

Fahr. and 220 deg. Fahr. (thermometer wrapped outside of pipe).

Time:

Minutes preparatory heating digester solution	198
Minutes feeding ore	78
Minutes elapsing between first and last appearance of colored NO_2	135
Pressure in digester	18 to 20 lb.

Gas:	Per Cent NO_2
Entering (average of four determinations)	7.05
Exit (when strong color was apparent at discharge)	2.7

Steam:

Average gage pressure 41 lb.

The steam heated 10,886 lb. of solution from 70 deg. Fahr. to 150 deg. Fahr. approximately.

Heat added by means of admission of steam was consequently 870,880 B.t.u. (assuming Sp. heat = 1).

Considering 12,000 B.t.u. derivable from 1 lb. of coal —then we have the equivalent $\frac{870,880}{12,000} = 72.57$ lb. of coal, and allowing for radiation and other heat losses, we have 100 lb. of coal required for preliminary heating of the acid solution.

At ratio of 1:3 = pulp:solution, and assuming cost of coal at $6 per ton, the figures given indicate a heating charge of about 16c. per ton of ore.

Air:

Assuming 29 per cent of the ore to consist of FeS_2, then from equation (1) we have, by the action of HNO_3 on 1610 lb. of ore, in round numbers 583 lb. of NO. The latter compound in forming NO_2 calls for 311 lb. of oxygen or almost 1355 lb. of air. The volume under standard conditions of 1355 lb. of air is 16,800 cu. ft.

In the test under consideration air was used for oxidation 140 minutes continuously. This would be at the rate of $\frac{15,800}{140} = 120$ cu. ft. per min. under standard conditions, if the whole of the ore was dissolved in accordance with equation (1) and the whole of the oxygen in the air utilized.

We actually used approximately 414 cu. ft. per minute, which indicates nearly 300 per cent excess over the theoretical of 120 cu. ft.

To compress 414 cu. ft. per minute to 40 lb. by single-stage compression requires about 46 hp. through 144 minutes. This power therefore is necessary to effect the oxidation of the NO derived by the treatment of 1600 lb. of ore, in accordance with the conditions obtaining in the test. Under the same conditions 2000 lb. of ore would call for 69 hp. through 144 min. per ton of ore for oxidation of sulphides.

If power costs are at the rate of 15 cents per horsepower day, these charges for air would be $1.04 per ton of ore treated in the case under consideration.

Ludwig, Nev.

Metallurgical Renaissance in England.—An announcement from the Institute of Metals (British) states that the last year has witnessed a remarkable growth in the institute's membership—from 660 to over 860. It is expected, in view of the war-stimulated "metallurgical renaissance"—as it has aptly been termed—that the 1000 mark will be passed in the present year.

Rubber and Jelutong

A Review of the Evidence in the Recent Customs House Dispute as to Classification of Gums

By Frederic Dannerth

A RECENT decision of the Board of U. S. General Appraisers has drawn attention to a matter which has for some time engaged the attention of rubber chemists, more especially since the New York Rubber Conference of 1912. I have in mind an officially recognized, standard nomenclature for terms used in the rubber industry. I believe it was Mr. Frederic Hood of Boston who spoke in favor of this at the time of the conference, and gave the impetus to the later discussions. In 1915 the Rubber Committee of the American Society for Testing Materials recognized the desirability of such a list of official definitions, and a committee was accordingly formed, with the writer as chairman, for the purpose of recording definitions as they are understood in the rubber trade. In 1917 (April 1) this journal presented a tentative list of terms used in the rubber industry, together with definitions for these terms showing the meaning applied to them in the American rubber trade. This list may be considered fairly representative, as it was scrutinized previous to publication by representative rubber importers, manufacturers and their chemists.

One of the deterrents in the situation has apparently been the so-called factor of "good judgment." This, so far as I am able to discern, is a method of buying and selling wherein the seller feels sure that he is selling his merchandise at a comfortable profit and the buyer feels equally confident that he knows more about the goods than does the seller. We have here, as it were, a case of "guess as guess can." This tradition has been applied in a great measure to the problem of definitions for crude rubber and rubber products. Just as this so-called "good judgment" is giving way to laboratory methods of testing the *value* of raw rubber, so the loose use of terms in the buying and selling of crude and raw rubber is being abandoned. The American rubber industry is most certainly to be congratulated on the progress thus far made in both these problems.

At the annual meeting of the Rubber Association of America, in 1917, that society described, by name only, certain standard qualities of rubber. The chemical and physical properties of the four standard qualities are still left to the variable known as "good judgment." The standard samples are on file at specified places, but are available for optical inspection only. The committee in charge of these official terms felt that if it appeared desirable later on to go into the matter more comprehensively this could still be done.

The American manufacturers of rubber-goods to day fully realize that rational specifications are rapidly displacing the "good judgment" of the old type of buyer. This holds good for the man who sells crude rubber to the rubber-goods manufacturer, and it also holds good for the manufacturer who sells the finished rubber product to a railway or a municipality. I am inclined to believe that many legal cases based on breach of contract would be impossible if buyer and seller would have a care to define the chemical and physical properties which the merchandise should pos-

sess. In a like manner many disputes arising from the assessment of duties by the Collector of Customs would probably be avoided if the importers themselves had a clear knowledge of the chemical and physical properties of the merchandise which they import. Bigger than all of this is, of course, the desire on the part of the importer to abide by the letter as well as the spirit of a tariff act.

One of the immediate results of this lack of definitions in the American rubber industry was the jelutong (or pontianak) case, heard in New York City in February, 1917. An importing firm had been called upon by the Collector of Customs to pay a duty of 10 per cent ad valorem on pontianak, it having been classified as *a non-enumerated, unmanufactured article,* under paragraph 385 of the Tariff Act of October 3, 1913. The importers claimed that it was entitled to free entry as crude rubber under paragraph 513.

In presenting the evidence for the consideration of the court the importers aimed to show that jelutong is known throughout the United States, and was known, on and prior to Oct. 3, 1913, as *crude India rubber.* They further expected to show by persons who manufacture articles out of it that it is known to them as rubber, used as rubber, and has no other use than as rubber. Some of the evidence presented was interesting, to say the least, and may serve to enlighten some of our rubber manufacturers. For example, one witness for the importers stated that jelutong was not used as a filler or an adulterant in a rubber compound. The inference here is that jelutong must belong to the class of materials known as rubbers. This is, of course, a lapsus, as it is commonly known that the substances which enter into a rubber compound are classified under possibly a dozen different heads, among which are adhesives, fillers, adulterants and rubber. The fact that jelutong is neither a filler nor an adulterant is not conclusive evidence that it is a rubber. The same witness stated that he knew of no substance other than rubber which could be used in a rubber compound to hold the several ingredients together. This hardly corroborates the experience of successful factory superintendents. The witness also stated that it is generally understood (in Boston and in New York, by the trade that engages in it) that jelutong is included in the commercial designation of rubber. If this be true, it would be well for dealers in rubber to take note of this remark, as it may enable them to deliver jelutong on any contract where "rubber" is specified.

Although the importers claimed that jelutong has for some years been known as crude India rubber, it was repeatedly shown in the testimony that the phrase "rubber" is rarely, if ever, used in buying and selling. The phrases that are used are "smoky sheets," "crepe," and the like, but the phrase India rubber, or the word rubber, is seldom used. The principal witness for the importers stated that jelutong is known to everybody in the trade, discussed and known by all users as rubber. On cross-examination it was, however, brought out that the matter had never been discussed by the witness with other dealers in rubber. One witness, who described himself as a compounding chemist, stated that the use of any of the various kinds of rubber will give to a compound the same qualities that the jelutong gives to the compound; that caoutchouc (the rubber hydrocarbon) is the prevailing ingredient of jelutong. This testimony was offered in the face of the fact that jelutong, when washed and dried, consists of approximately 25 per cent rubber hydrocarbon and 75 per cent resins.

One witness who testified to certain chemical facts in the case stated: "There are some nine hundred odd rubbers coming into the port of New York at different times." This is certainly a very generous estimate of crude rubber varieties, but rubber importers will accept this with considerable hesitation. He also testified, quite correctly, that rubber is the one material which shows both plasticity and elasticity. Fortunately for the importers, he forgot that pontianak (or jelutong) possesses little or no elasticity. It is for this latter reason that a considerable percentage of all chewing gum can be made of pontianak in whole or in part.

Owing to the pressure of bigger issues it was apparent that the Government did not secure the testimony of those who use jelutong, and so it was that some odd statements crept into the record without contradiction. Thus we find it stated that "jelutong is used in the same way and for the same purposes that other grades and qualities of rubber are used." In view of such testimony, the court had no choice but to sustain the protest and admit jelutong as "rubber." The whole case is of more than passing interest, and I have therefore taken some pains to bring to a focus our present knowledge concerning the character of the gum in dispute.

Trade Customs, Character and Uses of Jelutong

In one of the trade journals we find in September, 1913, that separate statistics are presented for "gutta jelutong" and for "India rubber." This makes a careful distinction between the two gums, and this distinction was never criticised.

Of all the jelutong produced in the East Indies in 1911 and 1912, a considerable portion was passed through a manufacturing process at the Goebilt-Sarawak Works of the United Malaysian Co. The process was known as deresination, and the products obtained as a result of it are: jelutong rubber (as residue) and jelutong resin (as extract). Samples of this jelutong rubber were exhibited in New York City in 1912 at the Rubber Conference, under the name "Malaysian crepe." (See Schidrowitz: Rubber, page 110, published 1911.) In May, 1910, that chemist made an inspection of the plant at Goebilt, Borneo, and later published his observations. The United Malaysian Company in 1912 published a pamphlet in which they recommend the use of jelutong in such proportions that 100 lb. of the compound or dough contains not more than 7 lb. of jelutong.

Potts, in his book, page 34, states: "An example of a highly resinous rubber is Malay crepe. This is obtained from jelutong, a *gum* containing (in its wet state) only about 10 per cent rubber. This is derived from the latex of *Dyera costulata.*

Jelutong cannot be used in the same way as rubber. The best results in vulcanization are obtained when the rubber used contains not more than 8 per cent resins. Experience shows that substances containing 15 or 20 per cent resins cannot be vulcanized in the usual manner.

Jelutong is a mixture of resins and rubber, and so is the commodity known in commerce as crude rubber, but the resins in jelutong have entirely different properties than have the resins of Hevea and similar rubbers. For example, the unsaponifiable matter is approximately 15 per cent in Hevea resins and 100 per cent in jelutong resins.

The specific rotary power is + 50 degrees for jelutong resins and zero degrees for Hevea resins.

The fact that jelutong is used in the United States principally by manufacturers of rubber products cannot affect the case, since there are numerous materials of which the same might be said (*e.g.*, vulcanized oils).

The characteristic which jelutong possesses which gives it its peculiar value is this: It renders the compound tacky or sticky, so that the compound can be used for binding together two surfaces, such as two layers of cotton duck used in building auto tires. Rubber itself does not possess this sticky character. These properties make it absolutely impossible to use jelutong in certain compounds. For example, no skilled chemist, versed in the art of rubber compounding, would use it in making auto tire treads or elastic bands or erasers. It is likewise a matter of common knowledge that no useful compounds can be prepared using jelutong and sulphur and omitting rubber. The fact that jelutong, after washing and drying, contains about 75 per cent resins and 25 per cent rubber, makes it undesirable for exclusive use as a substitute for rubber.

Proper Classification of Jelutong

A more correct classification for jelutong would be "a resin occurring naturally admixed with rubber, in the approximate proportion of 3 parts resin and 1 part rubber hydrocarbon."

Jelutong has been used successfully in the manufacture of chewing gum in the United States. Not merely the resins, but the entire material (after washing and drying) has been used.

Rubber of commerce is a material which, when admixed with sulphur in suitable proportions, can be vulcanized into a product having distinct properties of elasticity and tensile strength. The products so obtained can be applied to useful purposes. Jelutong does not comply with these requirements.

In order to produce useful products it is not necessary to mix or blend various rubbers. If in a given recipe, no other organic material but washed and dried Hevea rubber be used, a useful vulcanized product can be produced. If in a given recipe no other organic material excepting washed and dried jelutong be used, no useful product can be produced which will in the slightest degree resemble that obtained from the Hevea rubber.

Hevea rubber, plantation crepe, and Para rubber are terms well known in the American rubber trade. In order to obtain from jelutong a product resembling these it is necessary to put it through a manufacturing process known as deresination.

Hevea rubber is a material commonly included under the term rubber. It can be converted into useful products by mixing it with, say, sulphur and zinc oxide, and subjecting the mixture to heat while under pressure. Commercial jelutong cannot be converted into useful articles in the same manner. It has, to my knowledge, never been used exclusively in the production of commercial rubber goods. Whenever it is used in a rubber compound it is used in conjunction with some variety of rubber.

The amount of washed and dried jelutong which can be used in a rubber compound to produce useful products is limited to about 7 per cent.

It is my opinion that no manufacturer would be willing to accept jelutong, balata or guttapercha as a good delivery if he had ordered rubber.

(The first protest heard has been decided adverse to the Government, but new evidence having been gathered by the Department of Justice, a new case was prepared, and heard in December, 1917. No decision on the second case has been handed down at this time.)

The Rubber Trade Laboratory,
Newark, New Jersey.

Saving Ammonia Urged.—The Food Administration to-night issued an appeal to the owners and operators of ice-making and refrigerating plants to take every possible precaution against waste and leakage in their use of ammonia.

As a means of effecting ammonia savings owners and operators of plants were urged to institute a bonus system by which employees would be rewarded for effecting economies. Each plant will be required to report on the first of each month exactly what it is doing in saving ammonia.

"During 1918," the announcement said, "the Government should have for munitions alone 20,000,000 lb. of ammonia more than it is possible to make by working all plants in this country to capacity.

"This shortage will be greatly increased by the ammonia that will be furnished ice-making and refrigerating plants, but it is hoped that by appealing to the patriotism and the sense of all ammonia users and urging them to stop all waste and leakage, the usual consumption may be curtailed to such an extent as will permit at least the most efficient plants to run, particularly where natural ice is not available."

Releasing Shipping by Developing Our Mineral Deposits.—Secretary Lane has asked Congress for a special appropriation so that a large force of metallurgists can be set to work on the necessary changes in practice to use lower grade manganese ores, and that geologists and engineers can be employed to develop deposits of materials in this country which are now imported. In this manner Secretary Lane believes considerable ship tonnage can be released to carry food and supplies to France. The minerals most needed are nitrate, pyrites, sulphur, manganese, graphite, tin, mercury, potash, tungsten, antimony, chrome, magnesite and mica.

Payment of United States Patent Office Fees on Enemy-Owned Patents.—The War Trade Board has authorized the payment of United States Patent Office fees requisite for the filing, prosecution, registration and preservation of patents, trade-marks, prints, labels, or copyrights, of an "enemy" or "ally of enemy" by any person within the United States, where such person is the holder of a power of attorney granted by such "enemy" or "ally of enemy"; provided, however, that when such fees are to be paid from the funds of an "enemy" or "ally of enemy" in the United States, such payment shall be made subject to the approval of the Alien Property Custodian.

Recovering Ammonia at Tar-Distilling Plants

BY CLARENCE R. WOODWARD

ALTHOUGH it has long been known to tar distillers that a certain amount of ammonia is present in the water contained in ordinary coke-oven, gas-house or vertical-retort tars, the large manufacturers of this country have not up to recently considered that its recovery, if it could be effected, would be profitable to them. This opinion has probably been due to the fact that very little has been done in the way of experimenting to find the actual state in which the ammonia is present, its strength or the possibilities of recovery.

In the past two years the writer spent considerable time working on this subject at one of the plants of probably the largest of the tar distillers in the United States. The results obtained show that not only can ammonia be easily recovered, but that due to many favoring circumstances connected with the character of the equipment of a distilling plant, its recovery at these particular plants can be accomplished very profitably.

Sources of Ammonia

At the tar works there are two sources from which ammonia can be recovered; the liquor which settles out on the top of the crude-tar storage tanks and the liquor which comes over with the light oil in the process of distilling the tar. As the storage tanks are both filled and emptied from the bottom, this liquor settling on top of the tanks is commonly allowed to accumulate undisturbed until such time as the amount begins to take valuable storage space, when it is run to waste. The distilled liquor will be shown to be by far the most profitable source, due to its great volume and strength; but, as is the case with the settled liquor, it has usually been allowed to run to waste. It will be the purpose of this article to show how these liquors can be converted into a profit for the tar distiller.

At the particular plant at which the experiments to be described were made, the coal tar received in the course of a year consisted of about 9,000,000 gal. coke-oven tar; 4,000,000 gal. gas-house tar and 600,000 gal. vertical-retort tar. About two-thirds of this tar was distilled at the plant, the remainder being disposed of in a crude state for road-building purposes, under trade names tending to disguise its true composition.

Laboratory Tests

Before any large-scale operations were attempted, laboratory tests for ammonia were made on the water settling on the top of the storage tanks and on the water distilled from the different kinds of tars in the laboratory. The results given are expressed in ounces of ammonia per gallon of liquor and also in the percentage of anhydrous ammonia, the percentage being obtained by dividing the number of ounces per gallon of liquor by 3.88.

Tests of the liquor settling out from the tar in storage are given in Table I.

TABLE I—LIQUORS SETTLING ON TARS

Tank No. and Class of Tar	Volatile Ammonia, Oz.	Fixed	Total Ammonia, Oz.	Per Cent Ammonia
No. 2 coke-oven	1.41	4.39	5.80	1.50
No. 3 gas-house	.705	1.77	2.48	.64
No. 11 gas-house	.82	1.58	2.40	.62
No. 12 gas-house	.69	2.22	2.81	.73
No. 22 vertical-retort	No water settled out.			

An examination of the liquor distilled in the laboratory from each of the three different classes of tar, coke-oven, vertical-retort and gas-house, showed an *average* strength as follows:

TABLE II—LIQUORS DISTILLED FROM TARS

Class of Tar	Strength Ammonia from Laboratory Sample, Oz.	Total Ammonia, Per Cent
Coke-oven	9.76	2.52
Coke-oven plus NaOH	12.1	3.12
Gas-house	2.81	.73
Vertical-retort	8.5	2.19

In the distillation of these tars the condenser was kept at all times absolutely cold, so that never was there any danger of ammonia loss. Under these conditions the strength of the liquor obtained represents the maximum that can be recovered from these tars in practice. The second test with NaOH was made for the purpose of seeing if the fixed ammonia in the tar could be broken up in the process of distilling.

The results of the experiments on the settled liquor indicated that with the exception of that on the coke-oven tar the strength in ammonia was very low. In fact, were it not possible to mix them with stronger liquors, recovery of the ammonia contained in them would not be practicable regardless of the volume available. It should be noted that about 70 per cent of the ammonia in this liquor is fixed and would necessitate using lime in the process of concentrating.

The water distilled from the tar, however, is found to be considerably stronger in ammonia than the water separated from the tar on standing, and suggests very profitable recovery.

The great difference in the strength of these two classes of liquor is noticeable, particularly in the tests of the water from the coke-oven tar, which contains 5.80 oz. ammonia in the settled liquor and 9.76 oz. in the distilled liquor. This is probably due to evaporation of ammonia from the surface of the water in the storage tanks, an action which takes place to a greater or less extent, according to the heat of the tar and to the surface exposed to the air, and which causes a smaller amount of NH in the settled liquor. The fact that the tar itself contains some ammonium compounds aside from those in the water with which it is intimately mixed causes a corresponding increase in the amount of ammonia in the distilled liquor.

It is rather remarkable, however, that the water distilled from the coke-oven tar should contain 9.76 oz. of free ammonia while the water separating from the same tar on standing contains only 1.41 free ammonia.

The explanation is that the distilled liquor contains only free ammonia for the reason that when the tar is distilled the free ammonia passes over with the water and the fixed ammonia remains behind. In the settled liquor the free ammonia has evaporated from the causes mentioned above.

The result of the test with caustic soda indicates that an additional amount of ammonia may be recovered through the breaking up of the fixed ammonia remaining in the tar. It was not, however, considered worth while to try out this test on a large scale in view of the difficulties likely to be encountered through the action of the caustic on the tar.

Large-Scale Tests

Ammonia tests were now made on water obtained from the distillation of tar on a large scale, 10,000-gal. direct-fired stills being used. In the making of road-building material and pitch it is customary at this plant to mix coke-oven tar and gas-house tar in about equal proportions. Most of the tests, therefore, were made on the water distilled from such mixtures. However, to make the experiment more complete, a special still of straight coke-oven tar and a still of vertical-retort tar were run to fuel pitch for the purpose of obtaining the liquor from these particular tars. The water was caught in the usual 100-gal. drums, from each of which a sample was taken to be tested for its ammonia content. During the time the water was coming from the still the condensers were kept a little cooler than is usual when no attempt is made to recover ammonia. The average of several tests on the tar mixtures is given in Table III.

Table III—Ammonia Liquor from Mixture of Coke-Oven and Gas-House Tars

Tub No.	Total Ammonia, Oz.	Total Ammonia, Per Cent
1	11.50	2.96
2	5.80	1.49
3	3.90	1.01
4	1.90	.49
5	1.60	.41
6	1.17	.30
7	2.90	.75
	28.77	Av. 1.058
	Av. 4.11	
(Average of first 3 tubs, 7.07 oz., or 1.82 per cent.)		
Liquor from Coke Oven Tar	9.52	2.45
Liquor from Vertical Retort Tar	8.25	2.13

The strength of the liquor from these last two tars is found on comparison to differ slightly in strength from the tests of 9.76 oz. and 8.5 oz. obtained from the same tars in the laboratory. However, I believe the difference is no greater than should be expected in view of the necessarily great variation in the two methods of distilling and sampling.

The ammonia in all of these distilled liquors was found on testing to be approximately 99 per cent free and 1 per cent fixed. The small amount of fixed ammonia in the liquor is probably due to combinations made with the gases in the condenser, or with salt water which may have leaked through the condenser coils. The condensers are cooled with salt water.

It is interesting to note that in the results of the tests of liquor from the distillation of the mixed tar, the last pan, or tub, is stronger in ammonia than the three preceding it. This fact was rather puzzling at first, but I finally judged it to be due to the formation of NH_3 from the fixed ammonia $(NH_4)_2(SO_4)$ at high temperature.

$$(NH_4)_2SO_4 = NH_3 + NH_4HSO_4$$

According to Bloxom this breaking down begins to occur about 100 deg. C. and is complete about 300 deg. C. The temperature of the tar is usually about 160 deg. C. in the still as the last of the water is being removed.

Liquor Recovered in Practice

In order to ascertain if this ammonia liquor could actually be recovered without loss in practice, an 18-day test was run, during which time the liquor from all the stills instead of being allowed to run to waste was dumped into ground tanks and from there pumped into a storage tank holding about 5700 gal. When full, this tank was emptied, several samples being taken of the liquor as it ran from the bottom. In this test the liquor obtained was subject to some contamination from rain-water and from salt water dripping from the condensers, but the amount was not sufficient to affect the results materially. The tests given in Table IV are the average of the several samples taken from each tank.

Table IV—Analysis of Conserved Liquor

Tank No.	Gross Gallons Water	Ounces Ammonia Per Gallon
	4,982 { Not included	4.63
	5,734 { in total	4.01
1	5,734	3.84
2	4,892	4.88
3	5,734	3.94
4	5,358	4.07
5	5,734	4.46
6	5,640	2.77
7	5,295	3.95
8	3,290	5.12
	41,767	Average 4.17
	Tar 2,053	
	39,716 net gal. water for 18 days	

This water was all taken from mixtures of gas-house and coke-oven tars, and from the figures obtained it is evident that if care is used to prevent evaporation there is very little loss to be anticipated in recovering the ammonia. The average test of 4.17 oz. agrees very closely with the average strength of 4.11 oz. in the liquor as it is given off from the still and before it is dumped into the ground tanks.

The composition of the distilled liquor, containing as it does 99 per cent of its ammonia in a free state, constitutes a most favorable condition for concentrating for the reason that no lime will be required. Not only is considerable expense thus saved, but a troublesome step in concentrating is eliminated.

From the experiments made, it appears that the bulk of the liquor recovered at the stills when the usual tar products are being made will average 4.11 oz. strength, a liquor considered workable, especially in view of the fact that ammonia is in a free state and to the circumstance of cheap steam and water being always available at the works. Should it be found desirable, however, to obtain a stronger liquor at the expense of the total ammonia recovered, it is only necessary to eliminate the last few tubs of weak liquor. A strong ammonia liquor will always be obtained when straight coke-oven and vertical-retort tars are distilled.

Estimate of Profit

Records of the plant show that the total amount of water distilled from the tar in the course of the year

averages about 700,000 gal. The water settling out of the coke-oven tar in the course of a year is 76,000 gal. and that on the gas-house tars 256,000 gal.

Assuming all the ammonia concentrated to a liquor of 20 per cent strength, which has at this time a value of about $0.10 a pound at the works, the total amount and value would be at this plant:

Liquor settling on coke-oven tar:

76,000 × 8.35 × 15% = 9,520 pounds ammonia

Liquor settling on gas-house tar:

256,000 × 8.35 × .665% = 14,220 pounds ammonia

Distilled from tar:

700,000 × 8.35 × 1.058% = 61,840 pounds ammonia

Total ..... 85,580 pounds ammonia

Total value of ammonia, $0.10 × 85.580 = $8,558.

If any considerable amount of coke-oven tar or vertical-retort tar is distilled without admixture of gas-house tar, as is the case when ordinary fuel or briquet pitch is made, the amount of ammonia recovered will be greatly increased.

The only apparatus required in addition to that present in all distilling plants is an ammonia concentrator for concentrating the weak liquor, a few small tanks and a little additional piping. The same pumps and pump lines used for oil can be used for handling liquor, cheap steam is, of course, available and the labor, which is usually a small item in concentrating particularly when no liming apparatus is used, can be accomplished by the regular stillmen and the hiring of extra help avoided.

The cost of the concentrator, together with the tanks and including the labor of setting up, would be about $4,000. The operating cost of concentrating the liquor per pound of ammonia recovered is estimated in Table V:

TABLE V—COST PER POUND AMMONIA

Steam	$0.0066
Labor and supervision	0.0030
Lime	0.0005
Repairs, paints, etc	0.0010
Interest and depreciation	0.0059
Contingencies	0.0030
	$0.0200

The total value of the ammonia being approximately $8,558, and the cost of recovering $1,712, a profit of approximately $6,746 a year is indicated at this plant.

It is not necessarily true that the above results would be duplicated at every plant distilling similar amounts of tar, for, as is well known, the quantity of ammonia present in a tar will vary with different methods of recovering tar at gas works and with kind of coal used in these plants. It is believed, however, that the results will not be materially different from those cited except in plants where the tar is bought already dehydrated.

In the particular plant where these experiments were made the coke-oven tar secured by the distillers is made from New River coal and the vertical-retort tar from Westmoreland coal. The gas-house tar represents the average of 30 or more different tars obtained from perhaps as many different coals. The company appropriated $4,000 to this plant to cover the cost of installing the ammonia concentrator and the other necessary apparatus and if it proves successful they expect to instal a concentrator at their other plants. At the present time it should make a very profitable investment.

Melrose, Mass.

A Gas Dilatometer for Ascertaining Decomposition Points

Determination of the Decomposition Points of Cane Sugar, Dextrose and "Soluble Starch"

BY WILLIAM C. MOORE AND J. B. DAVIES

DURING a recent investigation in this laboratory it became necessary to determine the decomposition points of a number of organic materials. As the apparatus devised for this purpose has served us so well, it was thought that a description of it would be of interest.

In its essentials, the arrangement we made use of consists simply of a glass decomposition bulb which is immersed in a suitable heating bath; an outlet tube containing a horizontal expanded portion which serves as a combined air condenser and receiver for volatile substances distilled out of the material being studied, and a mercury manometer with a scale attached to measure the pressure developed.

The construction details are easily seen in Figure 1.

The heating chamber *A* is conveniently made from an 8-in. test-tube, to the upper end of which is sealed the riser *B*. The horizontal bulb *D* which serves as an air condenser can likewise be made from an 8-inch test-tube. The mercury-filled manometer is shown at *E*. The shorter tube of this manometer is about 810 mm. long; the longer, with the open end, about twice this length. A thermometer is used for measuring the temperature of the condenser *D*.

In making a run, an appropriate quantity of the substance to be decomposed is weighed into a small glass tube *G*. This tube is placed in an 8-inch test-tube, the latter drawn down to a neck and sealed onto a short piece of glass tubing which serves as the riser *B*. This is then sealed to the rest of the previously assembled apparatus just below the T. The outfit is now ready to be placed in position with the bulb *A* completely immersed in the heating bath. Sufficient clean, dry mercury is introduced into the manometer to form a column in the shorter tube, at least 760 mm. longer than that in the open tube after exhausting. In introducing the mercury, air bubbles can be dislodged by a piece of iron wire moved up and down in the open tube. This

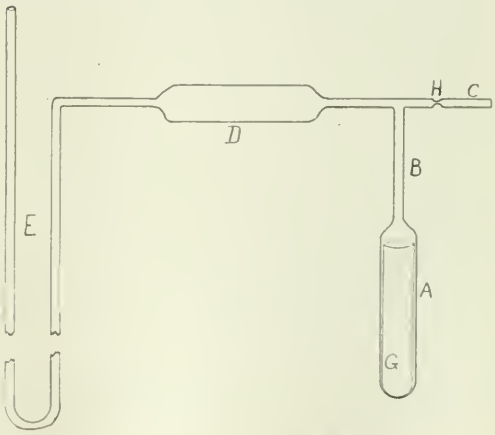


FIG 1. APPARATUS FOR DECOMPOSITION POINTS

wire must be long enough to reach the bend of the manometer.

The apparatus is now exhausted to a barometric vacuum through the outlet *C* and sealed at the constriction *H*. When all is ready the bulb is heated at a definite rate, readings being taken at regular intervals of the temperature of the heating bath, the temperature of the condenser, the difference in level between the mercury columns and of the barometric pressure. The total pressure within the apparatus is easily obtained by subtracting the difference in manometer levels from the barometer if the pressure is less than atmospheric,

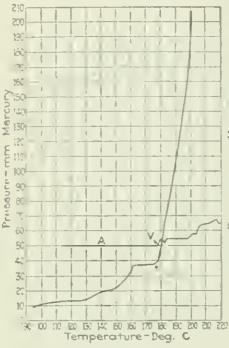


FIG. 2

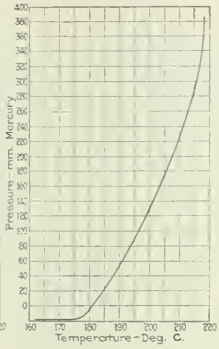


FIG. 3

or by adding these two quantities when the pressure is greater than the barometer reading. These pressures are plotted against the corresponding temperatures. In those cases where decomposition occurs, due to a permanent gas being formed by an irreversible reaction, the curve will show a sharp upward bend very similar to those shown in decomposition voltage curves.

If the condenser tube is not shielded from the heating bath, the temperature within it may rise to a high value. Where water is given off, the vapor pressure of the water within this part of the apparatus can readily be found from tables of vapor pressure of this liquid at different temperatures. This value may be subtracted from the total pressure to get the actual pressure of the permanent gas. However, proper shielding keeps the condenser tube at a fairly constant temperature which is approximately that of the room, in which event the vapor pressure of the water need not be taken into account since we are interested only in the singular points on the curve and not in the actual magnitude of

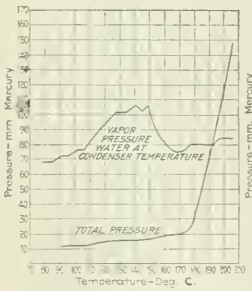


FIG. 4

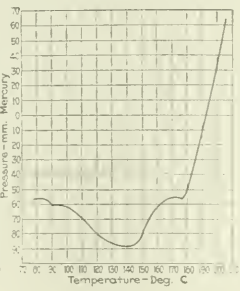


FIG. 5

the pressures developed. In some cases the rapid evolution of gas from the decomposing material will heat the condenser bulb also; this is shown on curve A* of Fig. 2 (Point V).

Working in the manner just outlined, the decomposition points of cane-sugar, dextrose and soluble starch were ascertained. In this case, the rate of heating was at about 1 deg. C. per minute up to 150 deg.; a little slower above that point. The heating bath was a large pail of paraffin which was continuously stirred by a paddle actuated by a motor.

Table 1 gives the summarized results. Figures 2 and 4 are the pressure curves obtained on two runs with cane-sugar. Figures 3 and 5 respectively are the corresponding curves after correction had been made for the water vapor in the apparatus. In Figure 5 it is possible that the contents of the condenser were not at as high a temperature as the outside thermometer showed.

TABLE I

DECOMPOSITION POINTS

Material Used	*Decomposition Point*
Cane Sugar	178 deg. C.; 177 deg. C.
Dextrose	177 deg. C.
Soluble Starch	214 deg. C.

Mercury in glass thermometer used.

The rate of heating is very important. Thus, at the slow rate of heating of 5 deg. per hour, cane-sugar decomposed at 155 deg. C., while soluble starch broke up at 185 deg. In these latter cases a Hoskins furnace up-ended was used as a large air bath.

This lowering of decomposition point by a decrease in the heating rate may be explained in this way; at a slow rate of heating, the sugar or starch molecules undergo some internal change which results in a less stable compound than the original sugar or starch being formed; while at a rapid rate, sufficient time does not elapse for such a change to occur.

Another possibility is that with very rapid heating (as at the rate of 1 deg. per minute) the material becomes superheated before decomposition occurs. With a number of other materials a similar elevation of the decomposition point was noted when the rate was changed from 5 deg. to 10 deg. per hour; this would indicate that with the 1-deg.-per-minute rate, the phenomenon is not due to delay in the decomposition material reaching the temperature indicated by the thermometer.

In order to correlate these results, work on other carbohydrates is planned.

A preliminary experiment, just completed, shows that a good quality of quantitative filter paper, when heated at 10 deg. per hour, did not exhibit a very sharp decomposition point; the evolution of gas began slowly at 143 deg.[1] There was some indication of a break at 185 deg. and a little sharper break at 204 deg. This material will be further investigated.

Research Laboratory,
National Carbon Co., Inc.,
Cleveland, Ohio.

*Curve A shows the vapor pressure of water at the condenser temperature.

[1]Hollings & Cobb (*J. Gas Lighting and Water Supply*, 132, 24, 1915; *J. Chem. Soc.*, July, 1915) have made a thermal study of the carbonization process. Altho they state that they attach no importance to the indications of their differential thermo-couple below 200° C., yet the curve they show for cellulose indicates that there is a gradual but considerable decomposition of this material, extending from a little under 150° C. up to 200° C.

The Physical Properties of Copper and the Factors by Which They Are Affected—III.

By Paul D. Merica
Division of Metallurgy, U. S. Bureau of Standards

(*Continued from page* 195)

Physical Properties at Higher and Lower Temperatures

1. Electrical Conductivity

Northrup (54) has determined the electrical resistivity of a sample of high conductivity copper from 20 deg. to 1450 deg. His curve is reproduced in Fig. 17.

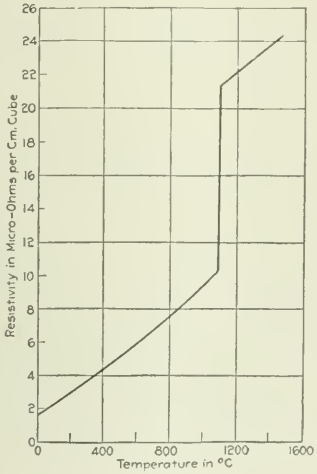


FIG. 17. THE ELECTRICAL RESISTIVITY OF COPPER AT HIGHER TEMPERATURES (54)

Dewar and Fleming (161) have determined in terms of platinum resistance temperatures the resistance of copper at low temperatures, using an electrolytic copper, drawn into wire without melting or heating, but subsequently annealed in hydrogen. Their results are as follows:

Temperature, Deg. C, Calculated By Dickson (162)	Temperature on the Platinum Resistance Scale	Resistance of Copper, Ohms (Meter, mm²)
201 7		0 029269
0. 55		0. 015639
−39. 4		0. 012975
−81 9	−78	0. 010243
−197. 1		0 002887
−206	−223 2	0 001436

2. Mechanical Properties

The mechanical properties which have been investigated at higher temperatures are chiefly those determined in the ordinary tensile test. Such determinations are complicated by several factors; the results are dependent upon the rate of loading and on the atmosphere in which the tests are carried out. It is not, therefore, surprising to find considerable variation in the results of different observers. An idea of the range of results may be obtained from Fig. 18, in which ultimate tensile strengths and elongation in 2 in. are plotted as a function of temperature at which the tests were made.

Bengough and Hanson (152) come to the following conclusions:

(1) "The nature of the atmosphere has an important influence on the results of tensile tests at high temperatures. An oxidizing atmosphere gives high ductility (at least with B.S. copper)at high temperatures.

(2) The existence of a range of low ductility in the neighborhood of from 250 deg. C. to 450 deg. C. is confirmed.

(3) Oxygen and arsenic lower the ultimate strength and increase the ductility at high temperatures." This last deduction is perhaps not in accordance with the well-known fact that arsenical copper softens upon annealing at higher temperature than pure copper. However, the yield point, not the ultimate strength, determines the latter characteristic.

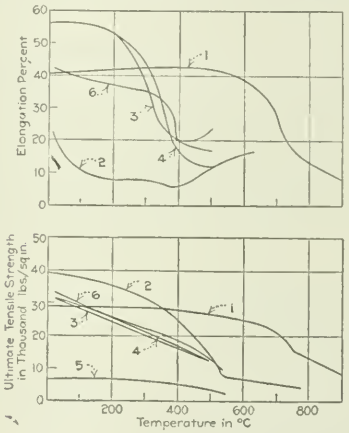


FIG. 18. EFFECT OF HIGH TEMPERATURES ON MECHANICAL PROPERTIES OF COPPER

Curves 1 and 2 (152) are for annealed electrolytic copper (oxygen, 0.08%; arsenic, 0.003%; iron, trace), and rolled arsenical copper (oxygen, 0.13%; arsenic, 0.13%; iron, 0.02%; lead, 0.10%; tin, 0.08%) respectively. The former was tested in air, the latter in CO_2; in both tests a constant rate (1.120 lbs./sq. in. per minute) of loading was used.

Curves 3 and 4 (156,157) are for annealed electrolytic copper (arsenic, antimony, selenium, tellurium less than 0.05%; bismuth, 0.0005%) and for arsenical copper (arsenic, 1.2%) respectively, tested in air. Curve 5 gives the yield point for the electrolytic copper. Rate of loading was not constant nor given.

Curve 6 is for "pure" copper (159).

Huntington (156, 157) has carried out alternating stress tests on copper up to 500 deg. C. and finds that the number of alternations to failure decrease with the temperature of test in much the same manner as does the ultimate strength.

Guillet and Bernard (153) have carried out impact tests on copper up to 1000 deg., and find a linear decrease of the specific impact work required to bend the specimens (none of the test specimens fractured).

Heat Treatment of Copper; Effect on Physical Properties

Cold-worked copper is softened by annealing, the ultimate tensile strength being decreased and the ductility increased. The temperature range within which this softening takes place most rapidly is from 200 deg.

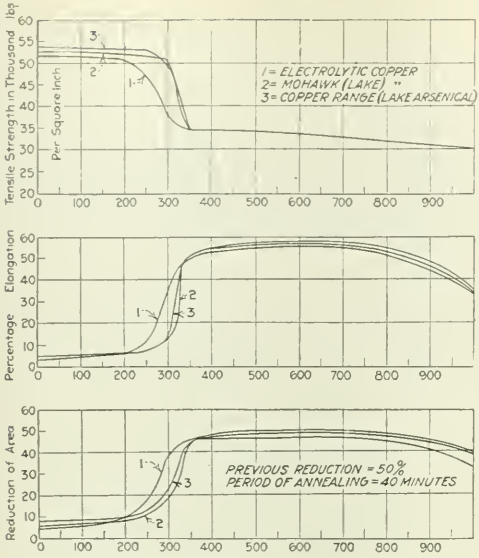

Tensile Strength in Thousand lbs. Per Square Inch
1 = ELECTROLYTIC COPPER
2 = MOHAWK (LAKE) "
3 = COPPER RANGE (LAKE ARSENICAL)
Percentage Elongation
Reduction of Area
PREVIOUS REDUCTION = 50%
PERIOD OF ANNEALING = 40 MINUTES

FIG. 19. EFFECT OF ANNEALING ON MECHANICAL PROPERTIES (TENSILE TEST) OF COMMERCIAL VARIETIES OF COPPER (191)

	% Oxygen	% Arsenic + Antimony	% Silver
Curve 1. Electrolytic copper	.071	.000	.0005
Curve 2. Mohawk copper (Lake)..	.052	.096	.069
Curve 3. Copper Range copper (Lake arsenical)	.055	.296	.052

Previous reduction, 50%.

to 325 deg. C. for pure copper, reduced 66⅔ per cent (186, 197), but is markedly affected by two factors:

(1) Extent of previous cold reduction,

(2) Presence of impurities.

Fig. 19 shows the annealing characteristics of three commercial grades of copper, the same, of which the characteristics were described on page 193 and in Fig. 16, and of which the analyses were then given. It is noticed that the presence of arsenic raises the annealing range of the copper.

Impurities such as arsenic and silver raise the annealing temperature range of hard copper; oxygen lowers it. This is seen from the curves in Fig. 20.

The range of softening temperatures for copper is lower the greater the previous cold reduction. This is shown in the curves of Fig. 21.

Bardwell has studied the effect of annealing in raising the conductivity of hard drawn copper wire. His curves are given in Fig. 22.

The properties of copper are not affected by a rapid cooling after annealing or rolling as are steel and certain copper alloys. It is generally held that quenching copper in water after annealing produces a softer metal than if it were slowly cooled; there is, however, evidence both for and against this view.

Martens (140) found that two similar bars of copper, cold-worked and annealed, of which one (a) was quenched and (b) was slowly cooled, possessed the following properties:

	Tensile Strength		Elongation in 10 cm., per cent	Reduction of Area, per cent
	Lb./Sq. In.	Kg. mm.²		
(a)	30,900	21.7	47.1	57
(b)	30,800	21.6	51.8	60

Johnson (261) also finds that his specimen EE, Table IX, which was cooled slowly after hot rolling has a greater ductility than two specimens of similar composition which were quenched.

Impurities in Copper; Effect on Physical Properties

The various physical and other characteristics of copper are affected in quite varying degree by the presence of impurities. Most markedly sensitive are the electrical and probably also the thermal conductivities and the mechanical properties (particularly ductility), especially at high temperatures, to the presence of impurities. The melting (also boiling) point is changed by the presence of impurities; information concerning this is given by the equilibrium diagrams of these elements and copper. It has been noted that the magnetic susceptibility is very profoundly altered by the presence of slight amounts of iron. Otherwise the effect of impurities in the amounts ordinarily found in good commercial grades of copper have but little influence on it. The specific heat, for example, is an additive constant. Practically no data are now available concerning the effect of small amounts of impurities on the characteristics of copper other than those mentioned

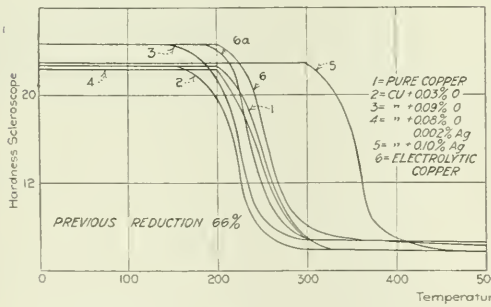

Hardness Scleroscope
1 = PURE COPPER
2 = CU + 0.03% O
3 = " + 0.03% O
4 = " + 0.05% O
0.002% Ag
5 = " + 0.10% Ag
6 = ELECTROLYTIC COPPER
PREVIOUS REDUCTION 66%
Temperature of Annealing in °C

FIG. 20. EFFECT OF IMPURITIES ON THE ANNEALING PROPERTIES OF COPPER (186)

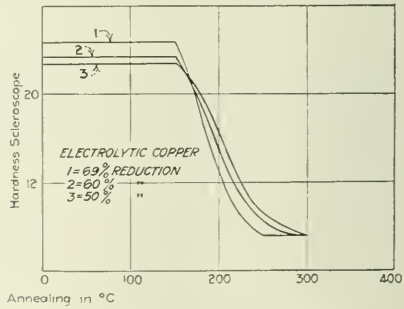


FIG. 21. EFFECT OF EXTENT OF PREVIOUS REDUCTION ON TEMPERATURE ANNEALING RANGE FOR COPPER (186)

1. Electrical Conductivity

Addicks (243) has investigated systematically the influence of impurities on the electrical conductivity of copper. He used high conductivity wire (99.5 to 101 per cent) in making up his alloy ingots; this was melted in a reducing atmosphere under charcoal with the added impurity. The ingot was cast in a heated iron mold, swaged down and drawn cold to No. 12 B. & S. gage. The wires were then all annealed by passing 110 amperes through them and tested. Fig. 23 gives a summary of the results of his tests. The presence of all of these impurities lowers the conductivity, arsenic, phosphorus and aluminium being particularly effective in this direction.

2. Mechanical and "Working" Properties

A great deal of investigation has been made of the effect of individual impurities on the mechanical properties of copper, not all of which has been conducted with a full recognition of the factors which must be considered in manufacturing conditions. A knowledge of the effect of an impurity in small amounts on the otherwise pure copper is undoubtedly valuable, but such copper is not a commercial product. From the practical viewpoint the effect of such impurities should always be considered in conjunction with that of the other usual impurities, principally oxygen. It is a fact that the effect, particularly of lead, antimony and bismuth, is most markedly altered by a variation of the presence of oxygen, arsenic, and other elements.

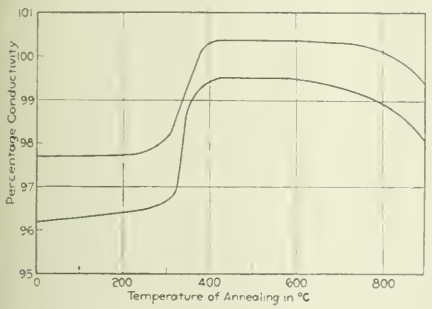


FIG. 22. EFFECT OF ANNEALING UPON THE ELECTRICAL CONDUCTIVITY OF HARD DRAWN COPPER (185)

	% Oxygen	% Arsenic + Antimony	% Copper + Silver
Material 1..	0.070	0.0038	99.92
Material 2..	0.046	0.0038	99.945

Previous reduction not given.

In considering the effect of individual elements a knowledge of the equilibrium diagrams of the binary alloys of these elements with copper is really necessary. Reference is made to these in the bibliography. The impurities to be considered may be classified according to whether moderate amounts of it are soluble as a solid solution in copper (manganese, nickel, zinc, tin, aluminium, etc.) or whether the impurity is but slightly soluble in the copper (bismuth, lead, etc.). It is then found in general that impurities of the former class harden copper, diminish its ductility, but increase its toughness and better its rolling and working properties, whereas those of the latter class do not harden the copper, but diminish both the ductility and the toughness and are quite injurious as regards the hot-working properties. The reason for this latter effect is to be found in the presence of the impurity as segregated particles or films of low melting point (300 to 500 deg. C.). The action of arsenic and oxygen is more complex.

Aluminium

The equilibrium of copper-aluminium alloys has been studied by Carpenter and Edwards (196), Curry (197), and Gwyer (198). Copper takes up approximately 9 per cent of aluminium in solid solution.

Some results of Johnson (261), Table IX, indicate the effect of this metal on the properties of copper.

Antimony

The constitution of the copper-antimony alloys has been studied by Hiorns (200) and Baikoff (199). From 2 to 3 per cent of antimony as Cu Sb are held in solid solution by copper.

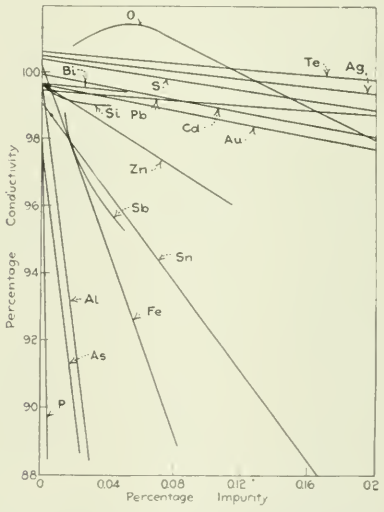


FIG. 23. EFFECT OF IMPURITIES ON THE ELECTRICAL CONDUCTIVITY OF COPPER (ADDICKS) (243)

Johnson (259) has studied the effect of antimony versus the mechanical and working properties of "tough-pitch" copper. He drew the following conclusions from his results, which are summarized in Table V:

"(1) Antimony up to 0.5 per cent has no detrimental influence on the hot-forging qualities of 'tough-pitch' copper free from other impurities. It is even possible to forge copper containing 1 per cent antimony if sufficient oxygen be present.

"(2) In copper which has been overpoled, antimony tends to mitigate the phenomenon of 'spewing' during solidification.

"(3) 'Tough-pitch arsenical copper (0.4 per cent arsenic) is slightly hardened after hot-rolling by the presence of antimony (0.2 per cent), but otherwise its mechanical properties are slightly improved.

"(4) The mechanical properties of 'tough-pitch' pure copper after rolling and annealing are but slightly altered by small additions of antimony. The tensile strength is slightly raised (5 per cent), and the elongation lowered (10 per cent). The slight gain in toughness is probably traceable to the greater soundness of the ingot.

"(5) With regard to the structural condition of antimony in 'tough-pitch' copper, it exists in two forms:

"(a) Partly in solid solution (as Cu_3Sb).
"(b) Partly as an insoluble compound with oxygen (slate-colored 'oxidules').
"Oxygen in excess exists as Cu_2O. The latter, together with the antimony oxidules, form a ternary eutectic with the solid solution."

TABLE V—INFLUENCE OF ANTIMONY ON "TOUGH-PITCH" COPPER, JOHNSON (259)

Specimens taken from rods rolled at red heat (900° C.) from 1¼-in. square ingots; rod rolled in 6 passes to ½ in., finished at dull red heat, annealed by raising to a bright red heat, quenched in pickling bath, rolled cold to 5/16 in., and straightened by drawing once through a die. All ingots were tough-pitch, with level surface; they all rolled perfectly. The copper used was the purest electrolytic (Viviao & Sons, Swansea).

No. of Ingot	Chemical Composition			Rods as Rolled			Rods as Annealed		
	Oxygen, per Cent	Arsenic, per Cent	Antimony, per Cent	Tensile Strength, Lb./Sq. In.	Elongation in 3 In., per Cent	No. Alternations to Rupture, Arnold Test	Tensile Strength, Lb./Sq. In.	Elongation in 3 In., per Cent	No. Alternations to Rupture, Arnold Test
RR	0.05	...	...	44,400	14.7	118	32,200	51.3	244
A3	0.058	...	0.2	43,700	13.0	136	31,900	43.3	210
A2	0.054	...	0.29	43,600	16.7	116	33,500	46.0	268
AA2	0.063	...	0.3	43,800	13.0	118	32,800	48.3	258
AA1	0.33	...	0.49	45,500	6.0	49	34,000	44.7	138
A	0.065	0.36	0.2	45,200	15.3	119	33,500	48.7	258

All of the ingots given in the table rolled well, hot; ingot A1, containing antimony, 0.5 and O_2 0.02 (overpoled), was red-short and was removed from the rolls at the third pass; samples of 5/8-in. rods were rolled cold after annealing into strips ⅛ in. thick. Rods RR, A, A2 and AA2 showed no edge cracking; AA1 showed edge cracking when a thickness of 3/16 in. had been reached.

There is much further information of a special nature in this paper and the discussion on it which will interest those desiring more complete information on this subject.

The earlier investigators of this subject were Hampe (253), Hiorns (256), Greaves (252), T. Johnson (264), Lewis (269), Archbutt (244). Hampe finds that copper with 0.53 per cent antimony can be drawn into wire, and with 1 per cent antimony is red-short. Hiorne finds that antimony (0.2 per cent) when added to copper containing lead (0.2 per cent) diminishes the brittleness caused by the lead.

Baucke (246) has determined the effect of antimony on the toughness (specific impact work necessary for fracture) of copper; see Table X.

ARSENIC

The constitution of the copper-arsenic alloys has been studied by Friedrichs (201) and by Bengough and Hill (202).

A compound Cu_3As is formed which is partly soluble in solid copper; the exact limit of solubility has not been determined; it lies probably between 1 and 3 per cent arsenic (i.e., copper will take up in solid homogeneous solution that quantity of arsenic as Cu_3As).

Next to oxygen this is probably the most important impurity occurring in copper. Lewis (268) and Bengough and Hill (247) have studied its effect on the mechanical properties of rolled copper; their results are summarized in Tables VI and VII.

Bengough and Hill summarize their mechanical tests as follows:

"(1) Arsenic in small quantities tends to increase the maximum stress without affecting appreciably the ductility of these alloys.
"(2) It increases their resistance to reducing gases at high temperatures.
"(3) Alloys with low percentages of arsenic tend to be unhomogeneous, but with increase in the arsenic this ceases to be apparent.
"(4) In ordinary oxidizing atmospheres no heat treatment (for three hours or less) short of an approximation to fusion seriously affects the properties of these alloys. The only result of annealing is to render the bars slightly more homogeneous and to lower the yield-point somewhat. This statement, however, does not apply to annealing temperatures in the neighborhood of 1000° C.
"(5) Alloys containing less than 1 per cent of arsenic are ruined by the action of reducing gases for three hours at 700° C. or above it; in some cases the action is apparent at 600° C.
"(6) The yield-points of these alloys are somewhat variable and unsatisfactory.

TABLE VI

Influence of arsenic upon the mechanical properties (tensile test) of rolled copper (Lewis, 268). Specimens were cast, rolled hot to ½ in. diameter and quenched.

Arsenic, per Cent	Tensile Strength, Lb./Sq. In.	Elastic Limit, Lb./Sq. In.	Elongation per Cent
0.00	26,800	14,000	25
0.24	33,800	20,000	27
0.53	36,800	19,000	29
0.75	36,600	18,000	21
0.94	36,000	18,000	25
1.37	37,700	20,000	28
1.80	35,700	23,000	20

TABLE VII—INFLUENCE OF ARSENIC ON MECHANICAL PROPERTIES OF ROLLED COPPER (BENGOUGH & HILL, 247)

Specimens prepared from B. E. R. copper and arsenic; alloy poled, cast into 3-in. ingots, rolled at good red heat with one reheating and finished by drawing cold with one ¾-in. pass to 1 in. and tested.

Chemical Analysis[1]				Physical Properties				
Copper	Arsenic	Oxygen	Sulphur	Tensile Strength,[2] Lb./Sq. In.	Yield Point,[2] Lb./Sq. In.	Elongation in 2 In.[2] per Cent	Reduction of Area[2] per Cent	Sclerescope No.[2]
99.055	0.04	....	0.005	34,800	14,000	58	79	11-15
99.733	0.26	0.12	0.007	35,300	21,000	40	79	11.3
99.344	0.75	....	0.006	35,100	14,000	57	79	11.0
99.052	0.94	0.15	0.008	37,100	19,300	54	70	10.5
98.055	1.94	0.20	0.005	37,900	14,000	62	80	10.5

[1]No trace found of lead, tin, or iron.
[2]Results are average of two tests.

According to these investigators arsenic in amounts up to 1.9 per cent causes, therefore, neither hot nor cold-shortness when, as usual, copper oxide is present, i.e., in tough-pitch copper. It seems that the presence of oxide affects the influence which arsenic exerts on copper. Roberts-Austen (275) find that 1 per cent arsenic begins to cause red-shortness in oxide-free copper. Jolibois and Thomas (262) state that 0.4 per cent arsenic causes cold-shortness in pure copper, whereas 0.4 per cent $As_2O_5.Cu_2O$ does not.

Baucke has studied the effect of arsenic on the toughness of copper; see Table X.

"Arsenical" copper such as is used commercially for copper which must resist high temperatures, in locomotive fire boxes, etc., contains from 0.1 to 0.4 per cent of arsenic.

BISMUTH

The constitution of the copper-bismuth alloys has been studied by Jeriomin (204), Portevin (203) and others. The amount of bismuth taken up by copper in solid solution is practically zero; it has never been accurately determined.

Johnson (261) has investigated the effect of small amounts of bismuth on the tensile properties, ductility and malleability of tough pitch copper. His results are summarized in Table IX. His conclusions are:

"The effect of bismuth on the mechanical properties of 'tough' arsenical copper which has been rolled is not

serious up to 0.1 per cent; but no commercial arsenical copper could be regarded as fit for working at a red heat which contained so much bismuth. With 0.02 per cent, although the hot-working properties would be noticeably worse than if no bismuth were present, the copper would not be ruined. Any crude copper containing over 0.01 per cent bismuth should be regarded with suspicion, since the copper might contain traces of other impurities, e.g. nickel, which, while intensifying the injurious effect of bismuth, would hinder the corrective action of arsenic."

Johnson also concludes that an explanation of the less intense effect of bismuth on the hot-rolling properties of oxygen-bearing copper is due to its presence therein as Bi_2O_3 or combination thereof as isolated particles, whereas in overpoled or oxygen-free copper the bismuth is present as films of metallic bismuth, which, owing to its low melting point, destroys the cohesion of the mass at high temperatures.

Other investigators of this subject have been Roberts-Austen (275), Hampe (253), E. A. Lewis (269), Arnold and Jefferson (245). Roberts-Austen made oxygen-free, bismuth-bearing copper alloys which could not be worked at all over 0.1 per cent bismuth. Lewis comes to practically the same conclusions as does Johnson regarding allowable bismuth limits and shows that whereas arsenic corrects the ill effects of bismuth, they are intensified by manganese, tin, aluminium, etc.

IRON

The constitution of the alloys of copper with iron has been studied by Ruer and Fick (211), Sahmen (210), and others. Copper will take up 2 or 3 per cent of iron in solid solution. Within those limits iron hardens copper and diminishes its ductility.

LEAD

The constitution of the copper-lead alloys has been studied by Friedrich and Leroux (212), Heycock and Neville (213), and others. The amount of lead which copper will hold in solid solution is very small, probably much less than 0.1 per cent. No systematic study has been made of the effects of lead on the mechanical properties. Its effect on the working properties at high temperatures is dependent on the amount of arsenic or Cu_2O present; 0.1 per cent of lead would render pure copper unworkable, whereas with 0.3 or 0.4 per cent arsenic such a percentage of lead is not out of the question.

Archbutt (244) was able to forge oxide-free copper ingots containing 0.05 per cent lead and those containing 0.1 per cent lead and 0.4 per cent arsenic without cracking of the ingots.

Johnson (259) states that the mechanical properties of arsenical copper at ordinary temperatures are but slightly affected by the addition of lead. Rods prepared by him (see Table V for method of preparation) containing oxygen, 0.023; arsenic, 0.39; lead, 0.18 per cent, showed the following properties:

	Tensile Strength, Lb. /Sq. In.	Elongation in 3 In., per Cent	Alternations to Rupture Arnold's Test
As rolled	41,200	17.3	169
As annealed	32,900	53.3	238
Original electrolytic copper			
As rolled	41,400	14 7	118
As annealed	32,000	51.3	244

The ingot of this leaded copper rolled well (see Table V for description of rolling), whereas one containing 0.012 per cent oxygen, 0.38 per cent arsenic, and 0.35 per cent lead cracked at first pass.

MANGANESE

The constitution of the alloys of copper and manganese is discussed by Sahmen (219), Schemtuny, Urasow and Rykowskow (218), and others. Copper and manganese form a continuous series of solid solutions.

Münker (273) gives results of tests of alloys of copper and manganese (see Table VIII), from which it is seen that manganese in small amounts hardens copper and diminishes its ductility.

Baucke has studied the effect of manganese on the toughness of copper (see Table X).

TABLE VIII[1]—EFFECT OF SMALL ADDITIONS OF MANGANESE, PHOSPHORUS, AND TIN ON THE MECHANICAL PROPERTIES OF COPPER (MUENKER, 273)

Composition	As Cold-Rolled, Unannealed			Annealed at 500° C.					
				Quenched in Water			Slowly Cooled		
	Ultimate Strength, Lb./Sq. In.	Elongation in 2 In., per Cent	Brinell Hardness Numeral	Ultimate Strength, Lb./Sq. In.	Elongation in 2 In., per Cent	Brinell Hardness Numeral	Ultimate Strength, Lb./Sq. In.	Elongation in 2 In., per Cent	Brinell Hardness Numeral
B. E. R.	52,300	4.24	94	34,100	46.07	74	32,500	46.64	63
Phosphorus[2]									
0.014%	52,900	4 04	96	35,100	45 08	74	32,700	46 54	63
0.042	55,300	3.89	101	35,800	44 10	74	32,800	45 84	65
0.092	57,000	3.43	112	35,900	42.98	74	33,600	44.80	68
0.173	57,800	3.33	118	36,600	41 44	74	34,600	41.70	70
0.399	60,500	3.27	130	37,400	39 81	77	36,300	40.74	74
0.563	66,200	2.46	145	41,200	39 74	84	38,500	40.02	77
1.062	75,900	2.28	160	46,800	38.14	96	41,000	39.87	84
Manganese[2]									
0.04	52,400	4.14	94	34,200	45.13	77	32,600	45.69	74
0.07	53,300	3.97	96	34,400	44 44	77	33,200	41.72	74
0.12	54,000	3.94	96	34,300	44.22	77	33,900	44.52	74
0.19	54,600	3.94	96	34,600	44.06	77	33,500	44.15	74
0.29	55,400	3.97	99	34,800	43.97	77	34,500	44.43	77
0.40	56,100	4.02	99	35,500	43 98	77	34,700	44.31	77
0.61	56,400	3.99	99	35,800	43 22	81	34,900	44 38	81
0.98	58,400	4.09	106	37,600	42.94	84	36,700	44 41	84
1.34	63,200	3.98	112	40,000	40.39	88	38,500	42.58	84
1 49	64,400	4.12	118	40,700	39.93	94	39,000	40.56	88
Tin[2]									
0.13	56,300	3.02	106	36,600	43.24	81	35,100	43.97	79
0.24	57,100	3.03	106	37,400	43.01	81	35,900	43.22	81
0.32	60,000	2.91	106	38,800	42 81	84	36,300	43.05	84
0.40	62,200	2.99	118	38,200	42 37	84	36,200	43.08	84
0.53	62,700	3 09	118	38,600	42 24	84	37,000	42.68	84
0.62	63,500	2.95	118	40,100	42.14	90	38,200	42.32	86
0.88	64,800	2.89	125	40,500	41.94	92	38,100	42.10	86
1.15	66,200	2.90	130	40,600	41.75	96	39,300	42.39	88
1.24	67,600	2 84	136	42,800	41.73	96	40 900	42 26	92
1.46	69,600	2.67	145	44,700	40.97	101	41,700	41.35	96

[1]The alloys were made under commercial conditions with B. E. R., copper and additions of phosphor-copper, tin-copper, and mangan-copper. The cast slabs were first hot rolled and then finished cold. Samples were annealed at 500° C. and either quenched or slowly cooled. The tensile tests were carried out on strips 3 mm. thick, 15 mm. wide, of a test length of 11.3 $\sqrt{\text{cross section}}$, or about 75 mm. The Brinell tests were made with a load of 500 kg. and a ball of 5 mm. diameter.

[2]The phosphorus alloys were otherwise as pure as the original B. E. R. copper; the manganese and tin alloys contained also from 0.012 to 0.020 per cent of phosphorus.

NICKEL

The constitution of the nickel-copper alloys has been studied by Guertler and Tammann (220), Tafel (222), and others. The two metals form a continuous series of solid solutions.

Small additions of nickel harden copper and diminish the ductility slightly, but apparently increase its toughness; see Table X (Baucke).

(To be continued)

Aluminium in 1917. — The value of primary aluminium made in the United States in 1917, according to the Geological Survey, was $45,882,000, an increase of $11,982,000 over the value of that made in 1916. This increase appears to be due chiefly to an increase in the quantity of metal produced.

Fats and Fatty Acids from Petroleum

By Robert J. Moore and Gustav Egloff

In considering the subject of the transformation of one class of oils into another of greater economic value, it seems advisable, as an introduction, to review the main classes into which "oily" matter in general may be divided. These classifications may be made first, through their physical properties and occurrence, and, second, by their chemical structure.

The term oil includes a vast number of substances, both natural and artificial, possessing widely different physical properties and chemical structure. All substances included in this term are practically insoluble in water, possess a characteristic greasy touch and have a low surface tension. This latter property forms the basis of the well-known definition that "an oil is a substance which, when dropped on paper, forms a translucent spot which is not removable by washing with water."

By the action of boiling alkali solutions we are able to separate oils into two large groups. One group splitting into fatty acids and free glycerine, a process which is called saponification, while the other group is not affected. The saponifiable oils are divided into animal oils and vegetable oils, depending on their origin. The vegetable oils are further classified according to physical properties into drying, semi-drying and non-drying oils and solid fats. The unsaponifiable oils are subdivided into mineral oils, which constitute the vast amount of petroleum and shale oils; rosin oils, tar oils and ethereal oils. The complete general system of classification is shown in the accompanying diagram.[1]

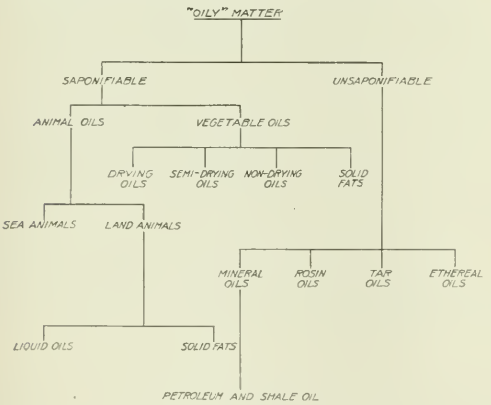


FIG. 1. CLASSIFICATION OF OILS

The naturally occurring animal and vegetable fats and oils consist essentially of mixtures of glycerides. Fats and glycerol esters of fatty acids when hydrolysed yield free glycerol and fatty acid, thus:

$$\underset{\text{stearin (glyceryltristearate)}}{C_3H_5(C_{18}H_{35}O_2)_3} + 3H_2O \leftrightarrow \underset{\text{glycerol}}{C_3H_5(OH)_3} + 3\underset{\text{stearic acid}}{C_{18}H_{36}O_2}$$

Since the glycerol radical is common to all, the nature of the fat depends upon the acid with which the glycerol is combined. These acids may be of the following groups:

[1] Southcombe's "Chemistry of the Oil Industries."

Series $C_nH_{2n}O_2$

Under this series occur

Butyric acid $C_4H_8O_2$ in butter.

Caproic acid $C_6H_{12}O_2$ in goat and cow butter, cocoanut fat.

Caprylic acid $C_8H_{16}O_2$ in human fat, butter, cocoanut oil.

Palmitic acid $C_{16}H_{32}O_2$ in many fats and oils.

Stearic acid $C_{18}H_{36}O_2$ in most fats.

Series $C_nH_{2n-2}O_2$.

Oleic acid $C_{18}H_{34}O_2$ is present in nearly all fats and fatty oils.

Other series, such as $C_nH_{2n-4}O_2$, $C_nH_{2n-6}O_2$ and $C_nH_{2n-8}O_2$, are found as glycerides in some of the fats; for example, linoleic acid ($C_{18}H_{32}O_2$) and linolenic acid ($C_{18}H_{30}O_2$) are found in linseed oil and other drying oils.

While small percentages of these free fatty acids may occur in the oils and fats, the main constituent is the glycerol ester. Thus we have tributyrin in butter fat, tripalmitin in palm oil, triolein and tristearin in most fats and oils.

The Mineral Oils

The chief division under the second general group of oils called unsaponifiable is the mineral oil division, embracing all petroleum and shale oils, and is the division to which we will, for the present, confine our attention. Petroleum oils are found widely disseminated in nature, the most important fields being the California, Texas, Mid-Continent, and the Eastern fields in the United States; the Russian, Galician, Roumanian and Italian in Europe, and the Mexican fields, which are now being rapidly developed. There are, besides these many productive districts in Asia and the East Indies. The world's production[2] for 1915 was 427,695,347 barrels, of which the United States produced 65 per cent. Russia ranks next in production and Mexico third. The total output for 1916 amounted to 460,639,000 barrels.

The hydrocarbons composing petroleums differ widely in nature. The Eastern oils are almost entirely of the paraffin or saturated series, the Mid-Continent semi-asphaltic, the California and Texas oils contain compounds mostly of the asphaltic type, while the Russian and Galician fields are mainly naphthenic.

The accompanying Table I contains hydrocarbons, homologs of which have been isolated in crude oil from the various fields:

TABLE I

Name	Formula	Occurrence
Paraffins	C_nH_{2n+2}	Pennsylvania; some in other American oils, only small percent in Russia.
Olefins	C_nH_{2n}	In Canadian and California oils. To small extent in Pennsylvania and other oils.
Naphthenes	C_nH_{2n}	Predominate in Russian oils. Franklin oils of Pennsylvania. Found to small extent in other crudes.
Asphaltic	C_nH_{2n-4}	In Texas and California oil.
Acetylenes	C_nH_{2n-2}	Baku oils in small amount.
Benzenes	C_nH_{2n-6}	To some extent in most crudes fair percent in California oils.
Phenylethenes	C_nH_{2n-8}	Slight extent; uncertain.
Phenylethines	C_nH_{2n-10}	Slight extent; uncertain.
Naphthalenes	C_nH_{2n-12}	Slight amounts in Rangoon oils.

The hydrocarbons which we are mainly interested in for present purposes are the paraffins, the naphthenes and the olefins. Our interest from now on will be directed to the many methods that have been offered for preparing fats and fatty acids from the above type hydrocarbons in petroleum oils.

[2] Petroleum in 1915, J. D. Northrop.

Conversion of Petroleum Hydrocarbons to Fats and Fatty Acids

The past work on this subject, all of which is of rather recent date, may be divided for simplification of narrative into four different methods:

1.—Through halogenation of aliphatic hydrocarbons.
2.—By way of Grignard's reaction.
3.—By way of naphthenes.
4.—Through direct oxidation of paraffins or olefins.

1. THROUGH HALOGENATION

In considering the problem of forming fatty acids from paraffins, the simplest method that might appeal to us is the conversion of a methyl group, of a boiling point in the neighborhood of 300 deg. C. into the carboxyl group. Thus hexadecane $CH_3(CH_2)_{14}CH_3$ boiling point 287.5 deg. C. might be oxidized to $C_{15}H_{31}COOH$ (palmitic acid) by the mere conversion of one methyl into a carboxyl group. The introduction of halogen into the paraffin seems to offer the most feasible first step in this reaction, and has been the subject of many patents. The Badische Anilin & Soda Fabrik[3] produce halogen derivatives of the paraffin series by mixing the oil and the halogen in the dark, vaporizing and subjecting the mixture to the action of the silent electric discharge. Halogenation takes place immediately. Pfeifer & Szarvasy[4] also use the silent discharge to effect the reaction, while Ellis[5] uses ultraviolet light for the halogenation of various hydrocarbons.

The writers, in a series of preliminary experiments, passed vaporized kerosene and chlorine, after heating, into an electrical silent discharge field of high potential, adding carbon dioxide at the same time. The experiments, though preliminary in nature, showed an increased specific gravity in the oil and a tendency to emulsify with sodium hydroxide solution. Indications are that a certain amount of fatty acids are formed under these conditions, the data of which will be given in a later communication. Further work along these lines is in progress.

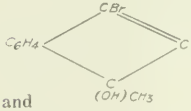
H. Strauss[6] produces monochlor compounds of the higher hydrocarbons of petroleum by treating in the gas phase, under reduced pressure, with chlorine. Information is lacking as to just how oxidation is effected, whether directly to acids or by way of alcohols and aldehydes.

As in most work on commercial problems of this sort, very little is stated as to details and yields. It is, however, quite possible to prepare fatty acids by this method, although its economic success probably depends upon further research.

2. BY GRIGNARD'S REACTION[7]

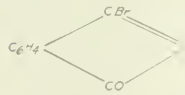
Zelinski[8] found that the reaction between magnesium and chlorinated hydrocarbons may be rendered complete by the addition of a catalytic agent such as iodine, aluminium halides or hydrochloric acid. He chlorinated the petroleum, dissolved it in anhydrous ether and treated this mixture with metallic magnesium and the catalyst. Subsequently, when cold, a current of carbon dioxide was passed through, decomposing the complex magnesium compound thus obtained. The fatty acids were then liberated from the magnesium compounds by dilute acid. Zelinski claims for this method a yield of 60 per cent of the theoretical. Pentane yielded isohexoic acid. A naphthene fraction (80-82 deg. C.) yielded cyclohexanecarboxylic acid, while a naphthene (71-79 deg. C.) yielded heptoic, methylcyclopentanecarboxylic and cyclohexanecarboxylic acids. He succeeded in synthesizing acids containing up to ten carbon atoms in the molecule, and in preparing a di- and tri-octin from an acid of the Formula $C_nH_{2n}O_2$ belonging to the same group as oleic acid, by heating the fatty acid with glycerine to 250 deg. C. While it is true that acids with more than ten carbon atoms show an essentially different action chemically from that of the lower fatty acids, still, if the lower acids may be so readily prepared, the synthesis of the higher acids is merely a matter of degree, which further research should make possible. Moreover, hydrogenation of unsaturation of unsaturated acids and bromine substitution is being rapidly improved, as a glance at recent patent literature will show, and the transformation to higher or lower acids is becoming more and more a commercial practice. The Vereinigte Chem. Werke of Charlottenberg has made a special problem of hydrogenation and has conducted it on an enormous scale, using a temperature of 100 deg. C. with 2 to 3 atmospheres pressure and 0.00002 parts of palladium chloride in an alkali as catalyst. In 1914 they predicted[9] that the synthetic production of fatty acids and fats from hydrocarbons by the process of Zelinski[10] was commercially feasible, but that the cost of the product was then still too high. Since the beginning of the war nothing authoritative has been published as to the German industries, *but it is not improbable that Germany to-day is supplying a large part of her fats from synthetic production.*

Bjelous[11] uses the Grignard reaction for the production of alcohols from olefins. This reaction is also used by Simmonis and Kirschten,[12] who have isolated and determined the composition of many halide compounds which may readily yield acids. Among these we find



1.2-dibrom-3-methyl indenol.

and



1-brom-2-iodine-indenol.

3. BY WAY OF NAPHTHENES

Naphthenes form the bulk of the Russian and Galician oils, and much experimenting has been done by Russian chemists on cracking and other forms of treatment of these hydrocarbons. Many investigators have

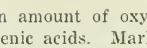
[3]Eng. Pat. 5125, 1912.
[4]U. S. Pat. 1012, 149.
[5]U. S. Pat. 1146, 142.
[6]Germ. Pat. 267, 204 (1912).
[7]Grignard's reaction employs metallic magnesium, the alkyl halide and anhydrous ether. The magnesium dissolves forming an alkyl magnesium halide as CH_3MgBr. When CO_2 is passed through this the addition product $CH_3CO.OMgBr$ is formed which upon hydrolysis yields the acid, thus:

$$CH_3CO.OMgBr + H_2O \rightarrow CH_3COOH + Mg(OH)Br$$

For further consideration of this reaction see Hewitt and Steinberg, *Proc.* Chem. Soc., 1912, 140; Zaretwitinoff, *Ber.*, 1912, 2384; Hibbert, *Proc.* Chem. Soc., 1915, 15; Simmonis and Kirschten, *Ber.*, 1912, 568.
[8]Ger. Pat. 151, 880; Ber. 1912, 2687 (Chem. Zeit. Rep. 1909, 631.

[9]See M. Colletas, *Mit. Gross.* 7, 4153, 1914
[10]Loc. cit.
[11]*Ber.*, 1912, 627
[12]*Berichte*, 1912, 568

found that a certain amount of oxygen is present in these oils as naphthenic acids. Markownikoff has isolated octanaphthenic acid,



and hexa, hepta, nono and deka naphthenic acids have been obtained from the alkali washings. E. Pyhalla[15] finds these acids present to about 0.9 per cent in Russian oils and suggests that they be neutralized with caustic soda, before refining, and made into soaps. He finds also[16] that the fraction of Baku petroleum boiling between 98 deg. and 106 deg. C. yields up to 20 per cent of its weight of adipic acid, which, by way of its amide, can be converted into butadiene and synthetic butadiene rubber. Pyhalla suggests that if these butadiene hydrocarbons could be isolated from the petroleum by a simple, direct process, this route to synthetic rubber would be a good one.

The production of glycerides from these free naphthenic acids is readily accomplished, but the resulting fat shows characteristic differences in properties from natural fats. The naphthenic fats are heavier than water (specific gravity 1.008 at 15 deg. C.), and tend to form plastic masses. This latter property has led to many patents for the production of India rubber substitutes, one of the most promising of which is Chercheffsky's.[15]

Naphthenes lend themselves to the Grignard reaction as readily as paraffins and have been used in Zelinsky's experiments.

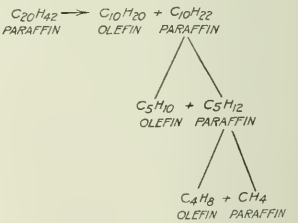
4. DIRECT OXIDATION OF PARAFFINS AND OLEFINS

Probably the most direct method of synthesizing the fats, and the method which, at the same time, seems to be of commercial significance, is the oxidation of paraffins and olefins to acids. This may be accomplished by air or other oxidizing agents and by way of alcohols or aldehydes. That the oxidation of even so inert an oil as paraffin vaseline can be made to yield acids is shown by the work of Benedix.[18] He intimately mixes the oil, in the presence of water, with sodium peroxide or hydrogen peroxide, diluted with alkalies and alkaline salts. After being stirred for some time, the mass thickens and part of the hydrocarbon is oxidized to acids, which combine with the alkali present to form soaps. The reaction is promoted by the addition of alcohol, and by heating to about 80 deg. C. under pressure. The resulting product is in the form of a soft paste, which "may be readily distributed in water and possesses great detergent power."

Schultz[17] by passing a rapid current of air through burning paraffin oil or hot lubricants obtained chiefly aldehydes, carbon monoxide and a small quantity of acids, but his work was rather crude and inadequate. Two recent patents,[18] couched in identical terms, are highly promising. In these experiments paraffin wax, in a molten condition, is treated with a blast of air or oxygen for a prolonged period, at a temperature of 100 deg. C. to 120 deg. C. The color changes to light red, light yellow and finally to a deep yellow. At this stage about 70 per cent of the wax has been converted into fatty acids, and a small quantity of alcohols, formaldehyde and the like. The different products are separated by distillation and the unchanged wax re-treated. Mercuric oxide or wax that has already been treated may be used as catalysts. By this process it seems possible to convert some 80 to 90 per cent of paraffin wax into fatty acids. The significance of this is readily appreciated. Moreover, Gray's experiments[19] seem to offer almost equally as favorable results. Gray blows air through the oil, at the same time subjecting to the actinic rays of ultraviolet light. With the assistance of heat (90-175 deg. C.), pressure and catalysts, such as finely divided metals, he converts part of the oil into fatty acids. With a lower temperature this process is used for the deblooming of certain paraffin oils.

Both of the above patents treat paraffin oils, which are saturated compounds and decidedly stable. It would seem advisable, therefore, to use as a starting material olefins which are unsaturated in structure and much more readily oxidized to acids. Olefins are not found to any considerable extent in natural petroleums, but a glance at the literature will show that they are readily obtained from petroleums in many ways.

Thorpe and Young[20] found that paraffins on being distilled under pressure at high temperature are decomposed into liquid hydrocarbons of the ethylene and methane series. Among the former were found up to nonylene. The general type of the so-called cracking reaction is as follows:



Gawalowski[21] finds that paraffins on prolonged heating alone yield gaseous and liquid products of the ethylene and acetylene series. Armstrong and Miller,[22] in investigating the by-products from the manufacture of Pintsch gas, found a high percentage of olefins up to crotonylene. The tars recovered from cracking Russian petroleum were found[23] to contain large amounts of hexylene and heptylene. Egloff and Moore[24] were able to prepare from 4 per cent to 95 per cent of olefin in the gasoline cuts from cracked paraffin oils by varying temperature and duration of reaction. In general, "high temperature of cracking makes for high unsaturation."[25]

Since the olefins are so readily obtainable from paraffin oils, and since they are readily oxidized, they offer an inviting field for experimentation. Greenstreet's[26] work upon this subject has led to the production of alcohol and fatty acids. He passes mineral oils mixed with steam through long coils of pipe heated to a cherry red

[13] *Petroleum*, 9, 1506 (1914).
[14] Neftanoje Djelo, 1913, No. 17; *Pet.* 9, 1376, 1914.
[15] Germ. Pat. 228, 558.
[16] Fr. Pat. 446,009, July 12, 1912.
[17] Eighth Int. Cong. App. Chem., 10, 273.
[18] Schmidt, Eng. Pat. 109,386; Feb. 13, 1917. Hulsberg and Selle; Swiss Pat. 75,653; Sept. 1, 1917.
[19] U. S. Pat. 1,158,205; Oct. 26, 1915.
[20] Liebig *Ann.* 165, 28.
[21] *Oesterr. Chem. Tech. Z.*, 70, 1910.
[22] *J. Chem. Soc.* 49, 74, 1886.
[23] Lewes, *J. Soc. Chem. Ind.*, 11, 584, 1892.
[24] *Met. & Chem. Eng.*, 15, 9, 1916.
[25] Hall, *Inst. Pet. Techn.*, 1915.
[26] U. S. Pat. 1,110,925, Sept., 1914.

thus cracking to olefins. The olefins are then oxidized and the products separated by fractional distillation. Oxidation may be effected by treatment with sulphuric acid to convert to the corresponding sulphuric ethers and then converted by water to alcohols. Or the olefins may be oxidized directly to aldehydes and acids by permanganate or chromic acid solution.

It is apparent from the foregoing work that fatty acids of various types may be prepared from petroleum hydrocarbons, in commercial quantities. Since, therefore, it is practicable to prepare certain fatty acids from petroleum, the question of changing to higher or lower acids, or from unsaturated to saturated acids, is being successfully answered in many recent patents, notably those of C. Ellis. Hydrogenation may alter acids as follows:

$$\underset{\text{linoleic acid}}{C_{17}H_{31}.COOH} + 2H \rightarrow \underset{\text{oleic acid}}{C_{17}H_{33}.COOH} - 2H \rightarrow \underset{\text{stearic acid}}{C_{17}H_{35}.COOH}$$

The carbon chain of fatty acids may also be broken down in many ways. A new method of accomplishing this is brought forth by Levene and West.[27] It consists in transforming the high fatty acid into its alpha-hydroxy-acid, which is then oxidized in hot methyl acetate with potassium permanganate. The potassium salt of the new acid is insoluble in the methyl acetate and precipitates, together with manganese dioxide, from which it is separated by hot alcohol. By this method Levene and West were able to obtain from stearic acid 80 to 85 per cent of margaric acid. Lignoceric and pentadecyclic acids were also formed from cerebronic and palmitic acids respectively.

It seems feasible, therefore, to prepare a fatty acid from petroleum oils that will have the same composition as an acid derived from natural fats. Or the acid formed may be so shifted by hydrogenation, or by breaking down the carbon chain, as described above, so as to finally produce the acids as found in natural fats.

The fats themselves, which are the glycerol esters of these fatty acids, may be readily prepared on a large scale by combination with glycerol. For this purpose may be employed such methods as heating with glycerol to 220 deg. C. under pressure,[28] by the action of Twitchell's reagent (sulpho-aromatic compound) on the acid and glycerol,[29] or by the action of enzymes.

The importance of the conservation and production of fats in this catastrophic period in world history can be gleaned from the following shortage and further developing shortage of livestock throughout the world.[30] The German army has taken from Belgium and France 1,800,000 head, and the herds of France had already decreased a year ago 16.6 per cent. To-day France is producing only one gallon of milk where two and one-half were produced before the war. The Allies, excepting the United States, have reduced their stock of cattle, sheep and hogs to the extent of 33,000,000 head since 1914 and the world stock to the extent of 115,000,000 head. According to Mr. Hoover, the per cent of hogs slaughtered in the fiscal year 1916-1917 was 96, while 86 per cent was slaughtered in 1916, and furthermore the average weight had fallen from 219 to 211 pounds per hog. In short, at the present time we have approximately 5,000,000 hogs less than our normal supply. The supply of cattle and sheep has been similarly affected hence it behooves us to search for commercial synthetic methods for the production of fats.

The foregoing work shows the extent to which the synthetic production of fats and fatty acids from hydrocarbons present in petroleum oil has been successful. Further work along the lines indicated by the writers is being carried on and will be reported upon in a later paper. It may be stated, however, that the collective work shows a considerable degree of success, and that "fats and fatty acids from petroleum" is more than an empty phrase.

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[27] *J. Biol. Chem.* 16, 475.
[28] Belucci, *Gaz. Chim. Ital. II*, 283, 1912.
[29] Krause, *J. Soc. Chem. Ind.*, 633, 1911. Iwanow, *Ber. Deut Botan. Ges.*, 595, 1911.
[30] New Republic, Feb. 2, p. 13, 1918.

Another Source of Toluol

Every possible source of toluol is being investigated by the War Department. It was brought out at the meeting of the Technical Association of the Pulp and Paper Industry on Feb. 6 and 7 in New York that toluol can be produced from spruce turpentine, which is an oil formed during the cooking of the chips in sulphite digesters, which escapes with the steam in the blowing-out process, and is generally allowed to go to waste, though processes of recovering this crude form of turpentine are carried out in a few mills.

A representative of the War Department, Milo R. Maltbie, was present at the meeting on Feb. 7 and explained the need for toluol and stated that it was understood that 300,000 gallons could be obtained from the mills in the United States at very little expense to the mills. He pointed out that it was a patriotic duty for all the mills to install the apparatus to recover this spruce turpentine and ship it to a central refining plant if the War Department finds it desirable after its investigation. A committee of the Technical Association was appointed to co-operate with the War Department in ascertaining the supplies of spruce turpentine that are available for toluol manufacture.

While the total quantity of toluol as estimated by Mr. Maltbie is not large, considering that he stated that he had put 3,000,000 gallons under contract during the last six weeks, still every available gallon helps and all sources must be developed.

Domestic Tin Production.—A report by Adolph Knopf of the Geological Survey gives the production of metallic tin of domestic origin in 1916 as 140 short tons. The ore was derived almost wholly from Alaska. The bulk of the concentrate was shipped to Singapore, but part was sent to the tin-smelting plant of the A. S. & R. Co., at Perth Amboy, N. J. The total importation was 74,619 tons and tin recovered from drosses 17,400 tons. Nevada, the Carolina tin belt and the Black Hills of South Dakota have been prospected with no definite production as yet announced. The production of tin (mostly from Bolivian concentrate) at Perth Amboy in 1917 was about 6000 tons. It is expected to be increased in 1918 to 10,000 tons. The National Lead Company's new plant is also producing tin, but actual figures for 1917 are not yet available. The production of this American tin has helped considerably at a time when foreign tin has been hard to obtain.

A Bibliography of Alloys

Binary, Ternary and Quaternary Systems Whose Equilibria Have Been Investigated

BY CLARENCE ESTES

IN A PREVIOUS article[1] the writer gave a bibliography of the binary, ternary and quaternary systems of alloys whose equilibria had been investigated and published in *Chemical Abstracts* to Jan. 1, 1917, and the more important investigations published prior to the publication of that magazine.

The following bibliography is to supplement the original article. It includes the articles on the equilibrium system of alloys, abstracted and published in *Chemical Abstracts* from Jan. 1, 1917, to Jan. 1, 1918.

The number preceding a system refers to the list of references in the original article.

BINARY SYSTEMS

No.	System	Chemical Abstract	Journals in Which Original Articles Were Published.
	Ag-Be	1917, 2630	J. Chem. Soc., *112*, II, 89
9	Ag-Cu	1917, 2851	Phys. Rev., *10*, 156
18	Ag-Pt	1917, 2851	Phys. Rev., *10*, 156
24	Ag-Te	1917, 447	Mem. Call. Sci. Kyoto Imp Univ., *1*, 361
	Al-Be	1917, 2630	J. Chem. Soc., *112*, II, 89
37	Al-Cu	1917, 2884	Metal Ind., *15*, 340
38	Al-Fe	1917, 3229	Univ. Ill. Eng. Expt. Sta., *95*
79	Au-Mn	1917, 2443	Z. anorg. allgem. Chem., *95*, 105
	Be-Cu	1917, 2630	J. Chem. Soc., *112*, II, 89
	Be-Fe	1917, 2630	J. Chem. Soc., *112*, II, 89
115	Bi-Sn	1917, 934	Z. anorg. allgem. Chem., *98*, 97
120	C-Fe	1917, 3225	Trans. Iron Steel Inst., *1917*
		1917, 3225	Eng. Expt. Sta., Pa., Bull. No. *18*
		1917, 3222	J. Russ. Met. Soc., *3*, 112, 148
		1917, 3220	Trans. Iron Steel Inst., *1917*
		1917, 2887	Sci. Rep. Tahoka Imp. Univ., *6*, 23
		1917, 2883	Bull. Am. Inst. Mining Eng., *1917*, 1365
		1917, 2882	Compt. rend., *165*, 172
		1917, 2882	Compt. rend., *165*, 182
		1917, 2881	Compt. rend., *164*, 885
		1917, 2881	Compt. rend., *165*, 1005
		1917, 2878	Phys. Rev., *9*, II, 228
		1917, 2768	J. Russ. Met. Soc., *3*, 78
		1917, 2767	J. Iron Steel Inst., *44*, 210
		1917, 2766	Proc. Roy. Soc. London, *93* (A), 313
		1917, 2765	Compt. rend., *165*, 59
		1917, 2451	Proc. Tokyo Math. Phys. Soc., *9*, (II), 112
		1917, 2449	Proc. Tokyo Math. Phys. Soc., *9* (II), 109
		1917, 2448	J. Russ. Met. Chem. Soc., *3*, 150
		1917, 1945	J. Iron Steel Inst., *1917*
		1917, 442	Proc. Am. Soc. Testing Materials, *16*, II, 5
		1917, 27	Iron Steel Inst., *1916*
		1917, 26	Iron Steel Inst., *1916*
147	Cd-Sn	1917, 934	Z. anorg. allgm. Chem., *98*, 197
	Ce-Co	1917, 2890	J. Chem. Soc., *110*, II, 35
	Ce-Fe	1917, 3229	J. Chem. Soc., *112*, II, 259
156	Co-Fe	1917, 1947	Can. Dept. Mines, Mines Branch, *1916*
167	Cr-Cu	1917, 2442	Univ. Ill. Eng. Exp. Sta. Bull., *93*
180	Cu-Ni	1917, 2879	Metall u. Erz., *14*, 21
		1917, 2442	Univ. Ill. Eng. Exp. Sta., Bull., *93*
		1917, 775	Metal Ind., *15*, 72
181	Cu-P	1917, 3228	Metal Ind., *15*, 386
186	Cu-Sb	1917, 3153	J. Russ. Phys. Chem. Soc. (Proceed), *48*, 700
		1917, 3153	J. Russ. Phys. Chem. Soc. (Proceed), *48*, 701
189	Cu-Sn	1917, 1124	Rev. metal., *12*, 405
194	Cu-Zn	1917, 2889	Foundry, *45*, 155
197	Fe-Ni	1917, 2882	Compt. rend., *164*, 904; U. S. Bureau Standards, Circ., *58*
211	Hg-K	1917, 553	Proc. Nat. Acad. Sci., *2*, 634
212	Hg-Li	1917, 553	Proc. Nat. Acad. Sci., *2*, 634
214	Hg-Na	1917, 553	Proc. Nat. Acad. Sci., *2*, 634
254	Mn-Sb	1917, 2888	Sci. Rept. Tahoka Imp. Univ., *6*, 9
	Se-Tl	1917, 143	Mem. Coll. Sci. Kyoto Imp. Univ., *1*, 153

BIBLIOGRAPHY OF THE TERNARY SYSTEMS

	B-Fe-Ni	1917, 3228	Rev. soc. russe metal., *1*, 547
24	C-Co-Fe	1917, 2449	Proc. Tokyo Math. Phys. Soc., *9*, II, 106
25	C-Cr-Fe	1917, 2450	Elektrochem Z., *37*, 592
26	C-Fe-Mn	1917, 3221	Compt. rend., *165*, 334
		1917, 2766	Compt. rend., *165*, 62
27	C-Fe-Mo	1917, 2451	Proc. Tokyo Math. Phys. Soc., *9* (2), 112
28	C-Fe-Ni	1917, 29	Proc. Inst. Mech. Eng., *1915*, 701
		1917, 3221	Compt. rend., *165*, 334
		1917, 2887	Arch. Sci. Phys. Nat., *43*, 453
		1917, 2886	Iron Age, *100*, 67
		1917, 2878	Phys. Rev., *9*, II, 228
		1917, 2768	Iron Age, *100*, 594
		1917, 2451	Proc. Tokyo Math. Phys. Soc., *9*, II, 112
		1917, 2449	Proc. Tokyo Math. Phys. Soc., *9*, II, 106
		1917, 1125	Atti. accad. sci. Torino, *51*, 67
		1917, 26	Phys. Rev., *7*, 685
		1917, 26	Phys. Rev., *7*, 684
	C-Fe-O	1917, 26	Verslag. Akad. Wetenschappen, *25*, 10
29	C-Fe-P	1917, 444	Iron Age, *98*, 1286
		1917, 26	Iron Steel Inst., *1916*
30	C-Fe-S	1917, 444	Iron Age, *98*, 1286
		1917, 26	Iron Steel Inst., *1916*
32	C-Fe-Si	1917, 2883	Bull. Am. Inst. Mining Eng., *1917*, 490, 991.
		1917, 1624	J. Chem. Soc., *110*, II, 623
		1917, 26	Iron Steel Inst., *1916*
35	C-Fe-W	1917, 2887	Sci. Rep. Tohoko Imp. Univ. *6*, 23
		1917, 2766	Sci. Rep. Tohoko Imp. Univ., *6*, 53
		1917, 2451	Proc. Tokyo Math. Phys. Soc., *9*, (II) 112
35	C-Fe-W	1917, 2450	Elektrochem. Z, *37*, 592
44	Cr-Cu-Ni	1917, 2442	Univ. Ill. Eng. Exp. Sta., Bull. 93
	Cu-Ni-W	1917, 2879	Metall u. Erz, *14*, 21

BIBLIOGRAPHY OF THE QUATERNARY SYSTEMS

C-Cr-Fe-Ni	1917, 3223	Met. Chem. Eng., *17*, 473
	1917, 2878	Proc. Am. Phys. Soc., *56*, 353
C-Fe-Mo-Ni	1917, 2451	Proc. Tokyo Math. Phy. Soc., *9*, II, 112

BIBLIOGRAPHY OF THE ALLOTROPIC MODIFICATION OF THE METALS

A	Ag	1917, 2290	J. Inst. Metals, *16*, 84
E	Bi	1917, 1355	Physik. Z, *17*, 346
		1917, 1067	Beibl. Ann. Physik, *40*, 227
G	Cd	1917, 2848	J. Am. Chem. Soc., *39*, 1806
H	Co	1917, 2875	Phys. Rev., *9*, II, 255
J	Fe	1917, 2878	Phys. Rev., *9*, II, 255
		1917, 2449	Proc. Tokyo Math. Phys. Soc., *9*, II, 107
		1917, 142	J. Chem. Soc., *110*, II, 883
M	Ni	1917, 2878	Phys. Rev. *9*, II, 255
N	P	1917, 2848	Chem. Weekblad, *14*, 180
		1917, 737	Z. Physik Chem., *91*, 756
Q	Sb	1917, 903	Phys. Rev., *9*, 138
	Te	1917, 903	Phys. Rev., *9*, 138

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[1] This Journal, Vol. XVI, No. 5, p. 273.

Increasing Magnesite Production.—Until 1915 the United States produced only about 10,000 tons of magnesite annually, although it used 300,000 tons. The domestic supply came from California and the imported material came from Austria, Hungary and Greece. In 1916 the production in California jumped to 150,000 tons, but the imports, if the calcined material is computed as crude rock, fell to 93,000 tons. The supply, therefore, fell short of the demand. Manufacturers of open-hearth steel had difficulty in getenough magnesite bricq to line their furnaces, and companies that made magnesite flooring were short of raw material.

In view of this condition and the decrease in imports, domestic production was greatly stimulated. According to estimates by C. G. Yale of the Untied States Geological Survey, the production of magnesite in California in 1917 exceeded that of all former years, being estimated at 215,000 tons. This quantity and the magnesite produced in the recently discovered field in Stevens County, Wash., estimated by R. W. Stone of the United States Geological Survey, at close to 100,000 tons, makes an output of about 315,000 tons in 1917.

Synopsis of Recent Metallurgical and Chemical Literature

Copper

The Separation of Copper During the Concentration of Copper Matte.—If during the concentration of ferruginous copper matte in the reverberatory furnace the copper content rises above 73-74 per cent, then, according to an article published by W. STAHL in *Metall. u. Erz*, 1917, vol. XIV, pp. 201-202, there is an increase in the separation of copper which normally takes place according to the reaction process:

$$Cu_2S + 2Cu_2O \rightleftharpoons 3Cu + SO_2$$

On adding a crude matte with a high ferrous sulphite content to a molten batch of enriched copper matte, there frequently occurs a special separation of copper which, in the further course of the concentration process, again disappears and is in no way connected with the above reaction. Again on smelting crude copper matte high in iron in the blast furnace there is frequently a separation of iron which is partly dissolved by undecomposed FeS. When the crude copper matte arrives in the crucible part of the dissolved iron will liberate copper from the slag according to the equation:

$$Cu_2FeSiO_4 + Fe = Fe_2SiO_4 + Cu_2$$

The remainder of the dissolved iron forms the solid compound $(Cu_2S)_2FeS$, with separation of copper, thus:

$$(Cu_2S)_2CuS + Fe = (Cu_2S)_2FeS + Cu$$

This reaction is not in contradiction with the Fournet series. The energy of combination of Cu_2S is known to be greater than that of FeS, yet the energy of combination of the sulpho-salt $(Cu_2S)_2FeS$ is apparently greater than that of $(Cu_2S)Cu_2S$. The separated copper again reacts with uncombined ferrous sulphide (a reaction accelerated by rabbling the molten matte).

$$4Cu + 3FeS = (Cu_2S)_2FeS + Fe_2$$
$$Fe_2 + O_2 + SiO_2 = Fe_2SiO_4$$

The cyclic process thus set up is only of short duration, as the small amount of free Fe is more readily eliminated by direct slagging than is the case with the free FeS, which sulphurizes the copper.

The Slagging of Nickel During the Poling of Copper to a "Set" Condition.—The operation of poling copper to a "set" condition, which follows the oxidizing fusion of high-copper matte, by rabbling and the skimming of the slag from the metal bath effects not only the removal of the absorbed SO_2, but also the reduction of the cuprous oxide (Cu_2O) dissolved in copper, by the reducing action of the gases evolved in the metal bath. With overpoled copper, according to W. STAHL (*Metall. u. Erz*, 1917, vol. XIV, pp. 202-203), it happens that the period of poling to a "set" condition is more a reduction than a gas-removal period proper. The enhanced slagging of nickel during the "dense-poling" stage is attributed by the author to the decomposition of a combination of cuprous oxide and nickelous oxide originally held in solution. As a result of dense-poling there takes place at first a reduction of free cuprous oxide, followed by reduction of some Cu_2O in combination with nickelous oxide, while the nickelous oxide itself remains unacted upon. As the nickelous oxide loses cuprous oxide, it becomes proportionately less soluble in the copper bath, until it finally liquates, combines with the acid radicals of silicates and ferrites, forming with the latter the tough, highly nickeliferous slag which is skimmed off. As a result of poling the copper to a tough-pitch condition (in which operation the layer of charcoal spread upon the metal bath assists the reduction) the remaining nickelous oxide of metal and slag is in turn reduced and the nickel retained in the metal bath.

Iron and Steel

Fatigue Failure of Boiler Plates.—E. B. WOLFF presented an exhaustive study of some obscure phenomena causing the cracking of boiler plates over the riveted seams before the Iron and Steel Institute (British), September, 1917. The cracks start as surface cracks of microscopical dimensions, each little crack being formed by itself, without reference to the position of its neighbors. Afterward, the cracks grow in length and depth and unite in longer ones, forming a peculiar stepped line. A polished and etched section through these cracks shows that the crystallites in the immediate neighborhood had not been deformed. The structure has also been found to be quite normal, no free cementite of segregations of importance having been found. All evidence pointed to a peculiar form of destruction of the surface layers of otherwise very plastic metal. Various tests showed that the material had not been sufficiently overstrained during fabrication to cause the trouble. The miniature cracks can be revealed and defective material discarded by etching the metal in 1:10 sulphuric acid for 24 hr. or more; before this treatment the cracks were covered by surface layers of oxides and were impossible of detection even after thoroughly scraping the plates. Microscopical sections through non-etched parts showed the cracks clearly. The only phenomena known where cracks of the kind described have been observed in plastic material is that known as "fatigue." Notwithstanding the severe conditions of the service, the number of alternations of stress is but few when compared to that number required to produce ordinary fatigue breaks. The author, then, by a careful study of the theory of stress in riveted joints, and the use of a special extensometer to show the distribution of stress in such joints, is able to show that the intensity of alternating stress at the parts which failed is well above the elastic limit, in which case, of course, only a comparatively few alterations are necessary to cause failure.

Composition of Rail Steel.—A test on the wear of street railway girder rails which extended over twenty-two years is reported by R. C. CRAM in the *Electric Railway Journal*, V. 51, p. 168. The Nassau Electric Railroad, Brooklyn, installed in 1895 several "soft" rails with carbon 0.28 per cent, and several "hard" rails containing what was then considered the high carbon of 0.59 per cent. The other metalloids were held as nearly equal as practicable in order that the effect of the carbon would be unmasked. Eight months later another line of rails "hard and tough" were added to the test—analyses of these rails being given in the table. At the present time the heads of all the rails seem to have worn

substantially the same amount, considering the narrow tread of the soft rail, and the shorter life of the hard and tough rail. Even so, corrosion of the rail base to such an extent as to prevent respiking has caused the replacement rather than wear on the head. The chief results are as follows:

	Soft Rails	Hard Rails	Hard and Tough
Height	7 3/16	8 35/32	8 25 32
Original head area	1.88	2.05	2.05
Amount worn, sq. in.	0.56	0.58	0.56
Per cent worn	29	28	27
Carbon	0.28	0.59	0.57
Silicon	0.026	0.056	0.234
Phosphorus	0.106	0.097	0.050
Sulphur	0.066	0.059	0.078
Manganese	0.790	0.83	0.95
Elastic limit	45,730	62,500	53,160
Ultimate strength	75,860	118,100	121,380
Elongation in 8 in., per cent.	24.3	11.9	11.5
Reduction of area, per cent.	51.6	18.4	20.0
Vertical wear, inches	0.4063	0.3437	0.3125

Potash, Nitrogen and Grease from Sewage.—X. H. GOODENOUGH, chief engineer, and H. W. CLARK, chemist, of Massachusetts Department of Health, reporting to an investigating board on the possibility of recovering fertilizing material and grease from Boston sewage by the Miles process, say that at Bradford, Leeds, Huddersfield, Oldham and Norwich, England, processes are installed treating material of much higher value than the Boston sewage. At Leeds, progress made indicates that in time they expect to arrive at an artificial process which will operate without nuisance, and make sufficient by the sale of by-products at least to pay the full cost of the disposal. In Germany the various plants erected for this purpose had one after another been abandoned as failures. Taking into account that the far richer wool-scouring wastes at Lawrence, Mass., almost go begging for utilization, there seems no present justification for spending money for a large scale experimentation with the Miles process.

In 1910 the average output from the first and second bowls of all the wool scouring machines at Lawrence amounted to 211,000 gal. per day, containing 29,000 lb. of fatty matters, 14,000 lb. of potash and 2200 lb. of nitrogen; that is, 0.14, 0.07 and 0.01 lb. per gal., respectively. At the present time two companies are faking the richest wastes amounting to about 80,000 gal. per day from the first bowls from nearly all the mills at Lawrence, and are making some profit. One company recovers only fatty matters, these being worked into lanolin. Plants for the recovery of grease from wool waste are also in successful operation at three or four other points in Massachusetts. Compared with the wool-scouring waste, the richest sewage of Boston contains 0.0006 lb. of fatty matter per gal., a very small amount of organic nitrogen, and practically no potash, the utilization of which constitutes a very difficult problem.

Analysis of Sulphur Burner Gases.—A paper on this subject was presented by F. M. WILLIAMS of Watertown, N. Y., at the recent meeting of the Technical Association of the Pulp and Paper Industry in New York. In the efficient operation of the sulphite mill, one of the most important considerations is the constant knowledge of the strength of the burner gas, SO_2, being produced. In the author's observation, the greatest variation occurs in the strength of the gas in different mills, as well as in the same mill at different periods. He has found some mills struggling along with weak acid troubles, when an analysis of the burner gas showed that they were trying to make acid with only 60 per cent SO_2 burner gas. The proper regulation of the burners by merely the appearance of the flame is much the same as trying to run a steam boiler at a definite pressure, without a steam gage.

There are two general methods of determining SO_2 in burner gases. First, by means of an instrument of the Reinsch type, in which a measured volume of gas is drawn through a standard iodine solution, which absorbs the SO_2. The principal objections to this method are that a single passage of the gas through one or two, or sometimes three, absorption bottles, does not in all cases absorb all of the SO_2 gas, and it is never possible to check the completeness of the absorption. Further, in the measurement of the complete volume of gas taken, we are dependent upon the volume of water which has passed out of the aspirator bottle, and it is necessary to apply various corrections for temperature, reduced pressure, and we always have the constant danger of error through leakage. A much more satisfactory method of analysis is the direct method, in which a measured volume of the sample is passed through a caustic potash solution in a suitable absorption pipette, after which the residue is returned to the original burette for measurement, and the operation repeated until a constant volume is obtained, the difference being SO_2 gas absorbed by the potash solution. This operation may be performed in various types of Orsat instruments.

A number of years of professional experience in sulphite mill work convinced the author of the need of a special modification of the Orsat particularly adapted to the analysis of sulphur burner gases. He has, consequently, developed a modified Orsat, known as the Williams Improved Gas Apparatus.

This instrument not only gives the percentage of SO_2 in the burner gas, but by means of the second or middle absorption tube a direct determination of the excess of air or oxygen is obtained. This is very important in burner regulation, and also in the determination of air leaks in the acid system.

In order to make the instrument equally available for the analysis of flue gases in boiler-room practice, a third or carbon monoxide tube is added, which makes it possible to determine quickly CO_2 oxygen and carbon monoxide.

In the first place, making acid with a 6 per cent gas, as against a 17 per cent or 18 per cent gas, requires about three times the length of time for makeup in a milk of lime system, with constant loss of production and a resulting acid of inferior quality. The same principle holds true in making acid in the tower system. Too weak a gas does not attack the stone readily, and it is impossible to obtain an acid of the desired quality.

On the other hand, there are troubles arising from too hot a fire, which would give a gas of sufficient richness, but will volatilize sulphur. While it is theoretically possible to obtain a gas by burning sulphur and air, of about 21 per cent SO_2, whenever this is reached in actual practice it has been the writer's observation that there has always been a volatilization of sulphur, and it would appear that a gas of from 17 to 18 per cent SO_2 is about the maximum practical working strength.

Recent Metallurgical and Chemical Patents

Electric Furnaces

Method of Starting Furnaces.—W. K. BOOTH of Chicago, Ill., patents a method of easily starting arc furnaces containing wall or hearth contacts, embedded in the lining of the furnace, whose walls, while conductive when hot, are virtually non-conductors in the cold. In starting up a cold furnace, therefore, the main electrodes rest upon the charge, and the common return in the hearth, being in effect insulated from the other electrodes, is replaced by an auxiliary electrode lowered through the roof to contact with the charge. This auxiliary electrode is manually operated, is electrically connected to the lines leading to the hearth contact, and remains in operation until the interior of the furnace becomes hot enough to allow the latter to function when the auxiliary electrode is completely withdrawn. (1,244,415; Oct. 23, 1917.)

Cooled Bottom Electrode.—MARTIN SPERLING of Essen-on-the-Ruhr, Germany (assigned to Krupps' A.-G.), patents a special design for bottom electrodes. Former construction calls for a hollow cone shape, cooled inside by a water stream. In a number of cases disastrous explosions have occurred in such electrodes due to the occasional insulation of several of the bottom electrodes from the smelting bath by pieces of clinker or refractory. The other electrodes then carry the entire load, which is in excess of the safe current density, bringing into incandescence the lowermost annular portion of the electrodes. The cooling water then gasifies with explosive violence. Sperling's construction is of low carbon iron and is illustrated in Fig. 1; it consists of a solid upper part d', a current collecting collar d^2 placed above a cooling cap D^2 and threaded electrode extension d^3, around which the water circulates. Current is thus led in through bronze plates F above the cooling water and into a solid conductor of large cross section and consequent large current capacity. Overheating is thus minimized, and contact of water and incandescent metal is impossible. (1,234,947; July 31, 1917.)

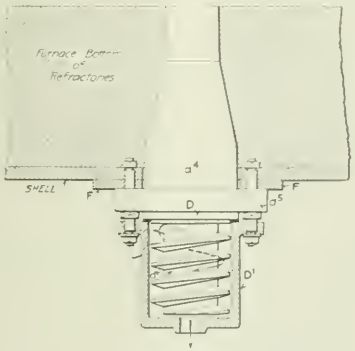


FIG. 1. COOLED BOTTOM ELECTRODE

Water Cooled Furnace Linings.—E. F. PRICE of Port Chester, N. Y., patents a method of protecting electric furnace linings from rapid destruction by air and moisture entering the fissures opened by temperature changes. Ingress of cooling fluid is prevented by laying 30-gage iron plates shingle-wise between the metal furnace bindings and the refractory lining. (1,239,214; Sept. 4, 1917.)

Low-Temperature Furnace.—I. R. VALENTINE of Schenectady, N. Y. (assigned to General Electric Co.), patents the furnace shown in cross-section in Fig. 2

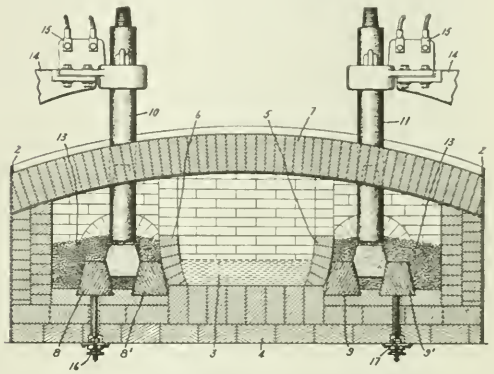


FIG. 2. LOW-TEMPERATURE FURNACE

for heating charges at relatively low temperatures in the hearth formed of carborundum brick (5 and 6). On opposite sides of the hearth are two continuous conducting prisms 8, 8', 9 and 9', supporting at intervals small graphite blocks located directly under the electrodes 10, 10' and 11, 11'. (10' and 11' are directly behind 10 and 11 and therefore not shown.) In operation current enters through electrode 11, arcs to the block below, is carried through 9 and 9' to another block, whence it arcs across to the second electrode 11'; thence back and forth through as many successive electrodes as is necessary by reason of the furnace construction. The arc is smothered by granular carbon. The central hearth is heated by conduction through the side walls and by reflection of heat rays from the arc to the roof. The use of arcs in series is flexible, easily controlled, and may use low amperage currents of high voltage. (1,242,275; Oct. 9, 1917.)

Brass Melting Furnace.—WOOLSEY MCA. JOHNSON of Hartford, Conn., patents a reverberatory melting furnace heated by a conducting grid, forming the roof of the hearth. The grid is composed of square carbon rods, acting as rafters, resting in niches in the side walls. Leading from rafter to rafter, and from the electrode blocks at either end, are short carbon bricks acting as purlins, loosely placed on the rafters. The whole may then be covered with as deep a layer of granular coke as is desirable. Some inert gas may be forced downward through the resistor toward the surface of the melt; this acts as a positive conveyor of heat, and will localize the current path near the bottom of the resistor bed by cooling the upper layers. A built-in stirrer to properly mix the melt is another feature of the invention. (1,243,416; Oct. 16, 1917.)

Hearth for Kjellin Furnace.—JAKOB FUNCK of Charlottenburg, Germany, has observed that the ordinary method of forming the trough-shaped hearth of

the Kjellin furnace, viz.: by ramming the magnesite in plastic condition around a templet, which is then removed and the mass baked by means of heating rings suitably placed in the hearth, is unsatisfactory owing to deformation suffered by the lining during the heating, and the binder at the surface is burned rather than coked, thus producing a pulverulent facing. He therefore proposes a massive iron template, which is left in place after ramming and which is electrically continuous, so that it is used as a heating element for drying and baking the new hearth. The latter is thus supported adequately during heating, and is entirely protected from the air up to the point where the template melts. The metal of the form then becomes the first charge. In case contact between hot metal and fresh lining is undesirable, the two are separated by asbestos board or other neutral refractory. (1,226,764, May 22, 1918.)

Current Control.—J. A. SEEDE of Schenectady, N. Y. (assigned to General Electric Company), patents a method of current control to electric furnaces, whereby reactance is placed in the main circuit without interrupting the current. He provides reactance devices or transformers 12 and 13 (Fig. 3) where the main fur-

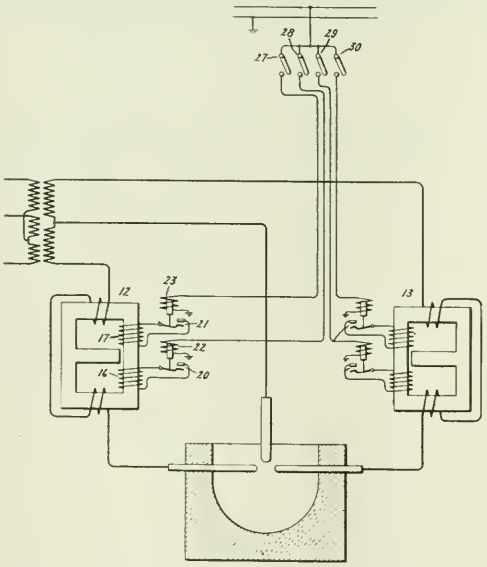


FIG. 3. WIRING DIAGRAM WITH REACTANCE IN CIRCUIT

nace supply lines form a primary winding 14 of a few turns. Secondary windings 16 and 17 may be short-circuited at 20 to 21 by solenoids 22 and 23 remotely controlled. By closing switches 27 to 30, any number of the secondary coils will be short-circuited, thus reducing the reactance in the supply mains. The larger the comparative number of turns in the secondary winding the smaller the current in that circuit and the more readily interrupted. The correspondingly increasing voltage will not be inconvenient, since the arc voltage is usually low, of the order of 100 volts, while the amperage may be many thousand. The arrangement is said to be inexpensive and reliable. (1,242,250; Oct. 9, 1917).

Miscellaneous

Increasing Capacity of Sulphuric Acid Plants.—A method for increasing the density of the sulphur dioxide entering into the manufacture of sulphuric acid is patented by MARION L. HANAHAN of Dothan, Ala. The pyrites burners used are of the ordinary construction and the gas chamber in the top is connected by a flue to a dust chamber. The flue enters the dust chamber at a point about midway between the top and bottom, and the dust chamber has an outlet near its upper end which opens into a flue. The niter oven is located between the dust chamber and pyrites burners and below the flue connecting these.

A cast iron shallow pan or container is supported on the floor near the bottom of the dust chamber. This pan is designed to hold commercial sulphur when the same becomes molten and is burning. The commercial sulphur is charged in the pan through a door cut in the side of the dust chamber opposite the sulphur container. An air pipe extends through the wall of the dust chamber and over the pan and has one or more openings to supply air or oxygen under pressure in close proximity to the sulphur in the pan. This oxygen or air is necessary to support the combustion of the sulphur in the pan to provide the sulphur dioxide. The heat necessary for melting and burning the sulphur in the pan is derived from the heat of the gases entering the dust chamber from the pyrites roaster. The sulphur dioxide produced by the burning of the sulphur in the pan in the presence of air supplied by the pipe rises and commingles with the sulphur dioxide entering the dust chamber from the pyrites roaster and the excess sodium nitrate carried by the latter gas is sufficient for the additional sulphur dioxide produced by the burning sulphur in the pan. (1,253,238, Jan. 15, 1918.)

Preparation of Alums from Clay.—LOUIS L. JACKSON of New York, N. Y., proposes to treat clay in an uncalcined condition and heat it with niter cake at a temperature of at least 150 deg. C., but at a temperature below that needed to calcine the clay and below that needed to decompose the niter cake alone. Silica, soda alum and sodium sulphate are formed, the silica being in an insoluble condition, whereas in the common process a considerable quantity of the silica is soluble. The soda alum and sodium sulphate are dissolved out with water and separated by crystallization.

Ammonium sulphate or potassium sulphate may be added in the proportion of one molecule of the sulphate to each molecule of alum, and the more sparingly soluble ammonia alum or potash alum may be obtained. While the temperature must exceed 150 deg. C., it is uneconomical to employ a temperature much above 400 deg. C., but it would be possible to get good decomposition at any temperature above 400 deg., at which all the products used and made are stable if heated by themselves. A temperature of about 350 deg. C. is preferred. (1,254,229, Jan. 22, 1918.)

Decomposing Magnesium Silicates.—LOUIS L. JACKSON of New York, N. Y., proposes to render the natural silicates, such as talc, soapstone, chrysolite, etc., soluble in acids by heating at a relatively low temperature with a large excess of caustic alkali. They are decomposed into an alkaline silicate and a silicate of magnesium which is readily soluble in acids, even in very dilute acids (for example, 1 per cent sulphuric acid), or even

diluted organic acids like acetic acid. Using twice the theoretical quantity of caustic alkali and heating even as high as 600 deg. C. for two hours, only about one-half of the soapstone is decomposed; while by using four times the theoretical amount, almost complete decomposition may be obtained in the same time at 350 deg. C., or even at a lower temperature. As the caustic alkali is recovered and used over again, there is no objection to using this large excess. (1,254,230, Jan. 22, 1918.)

Tanning Compound.—A sulphuric acid tanning compound is patented by OTTO SCHMIDT and ARTHUR ANDRES of Ludwigshafen-on-the-Rhine, Germany (assigned to Badische, Anilin and Soda Fabrik). An example of the preparation of this compound is given as follows:

"Shake together for some time, 94 parts of phenol, 22 parts of paraldehyde, and a small quantity of concentrated sulphuric acid. As reaction takes place heat is evolved, and care should be taken that the temperature does not rise above 90 deg. C.

"When the reaction is complete, add 100 parts of 97 per cent sulphuric acid and stir, while warming gently, until the reaction product is soluble in water. Take a concentrated solution of this compound, partially neutralize it with caustic soda solution and then dilute it with water until a solution of 2½ deg. Baumé is obtained. Then add ten grams of common salt to each liter of this solution and employ it for tanning. Leather is obtained which, after being treated with fat, possesses a good resistance to tearing. (1,254,364, Jan. 22, 1918.)

Potash

Potash from Tobacco Plants.—WM. H. KENNEDY and GILBERT E. BAILEY of Los Angeles, Cal., patent a process of extracting potash from the stems, ribs and leaves of the tobacco plant not ordinarily used in the manufacture of cigars, etc. The tobacco is percolated with denatured alcohol and the extracts withdrawn. The gums and resins are distilled from the residue and the residue is then roasted in the presence of charcoal to form carbonates, which are then leached with hot water to extract the potassium carbonate which is subsequently recovered. (1,253,497, Jan. 15, 1918.)

Potash from Feldspar.—EDWARD L. ANDERSON of Pittsburgh, Pa., patents an electrolytic process of obtaining potash from feldspar. Feldspar or the like material may be decomposed by electrochemical means with a relatively small amount of electrical energy by first mixing an insoluble conductive material, such as carbon or a carbon compound, so as to make the mixture a conductor of electricity. This mixture is packed in the anode compartment of a cell having a porous partition between anode and cathode compartments. The mixture is saturated with water containing five or ten per cent of hydrofluosilicic acid. The cathode compartment is filled with water. The action of the electric current is to decompose the feldspar, producing potassium hydroxide in the cathode compartment and a mixture of aluminum oxide and silica in the anode compartment. (1,253,560, Jan. 15, 1918.)

Potash from Glauconite (Green Sand).—FREDERICK TSCHIRNER of Newark, N. J., patents a process of extracting potash from green sand, which is briefly as follows: One hundred parts by weight of green sand marl (glauconite) are mixed with fifty parts of lime sand (gray calcareous marl) and thirty parts of calcium chloride. This mixture is submitted to a roasting temperature with access of air to a temperature of about 800 to 820 deg. C., care being taken to avoid a heat sufficient to form clinkers. The first result of this roasting is to dehydrate the green sand and convert the calcium carbonate largely into calcium oxide. In the presence of the calcium oxide so formed, the calcium chloride acts on the dehydrated green sand, whose ferrous salts have been converted into the ferric condition by oxidation and produces potassium chloride. The lime also reacts with any soluble ferric salts, *e. g.* chloride to produce ferric oxide and calcium chloride. This mixture after roasting can then be leached either with or without powdering and the potassium chloride can then be extracted. (1,254,450-1, Jan. 22, 1918.)

Separation of Potassium and Sodium Salts.—JOHN R. MACMILLAN of Niagara Falls, N. Y., patents a process of recovering high grade potash salts, which is assigned to the Niagara Alkali Co. He employs the differential solubilities of the carbonates and bicarbonates to give a separation in a single operation. The solution (with or without preliminary separation of normal sodium carbonate by cooling to 5 deg. C. to 0 deg. C.) is treated with carbon dioxide gas at a temperature of 20 to 30 deg. C. This converts the alkalies into bicarbonate and the sodium is precipitated. The solution is then cooled to 1 deg. to 5 deg. C., when crystals of pure potassium bicarbonate will be formed. These crystals when dried, with ordinary washing, contain, ordinarily, not over 2 to 4 per cent sodium bicarbonate and under 1 per cent sulphates and chlorides even in the case of solutions containing much sulphate and chloride. (1,254,521, Jan. 22, 1918.)

Potash from Glauconite (Green Sand).—WALTER GLAESER of Fullerton, Pa., patents a process of treating glauconite, which is assigned to the Potash Extraction Corp. of New York. The finely ground green sand is mixed with about sixty per cent of its own weight of calcium chloride and 5 per cent of coke, and the mixture heated to 270 deg. C., to drive off the moisture. Air is excluded in this operation. The mixture is next heated to 800 deg. C., in a non-oxidizing or reducing atmosphere. In this step potassium chloride and a silicate of iron and calcium are formed. (1,254,676-7, Jan. 29, 1918.)

Potash from Feldspar.—A process of producing alkali carbonates, containing small amounts of alkali hydrates, from alkali rocks is patented by HARRY W. CHARLTON of New York. In treating feldspar from 3 to 6 parts of same is digested with 7 to 2 parts of a mixture of lime and calcium carbonate in 44 to 26 parts of water at pressure above 200 lb. and corresponding temperatures. Most of the potash is thereby extracted. The residue is white and is used in making brick. (1,256,295, Feb. 12, 1918.)

Electric Furnaces in Canada.—Discussing the subject of electric smelting in an address at the recent annual meeting at the Commission of Conservation, Sir Clifford Sifton said that there are, at the present time in Canada, 32 Heroult electric furnaces and 22 of other types—54 furnaces in all, with a capacity of 173,000 tons of iron and steel, 50,000 tons of ferrosilicon, and 8000 tons of other ferroalloys per annum.

A New Method of Microscope Illumination

By Alexander Silverman*

FEELING the need for an illuminator which would furnish diffused light for examination of opaque objects and which could be lowered into hollow objects, the writer has devised the following microscope accessory:

A circular tube containing a tungsten filament is separably attached to a ringlike holder (Fig. 1), which by means of three centrally protruding fingers, controlled by springs, is clamped to the microscope objective (Fig. 2). The holder may be raised or lowered to modify the quality and intensity of the light. The lamp is made of colorless or blue (daylight) glass having a white reflector on the upper portion, and in models in use requires 0.7 ampere and 6 volts. It can be connected to a 110-volt lighting circuit with a resistance in series, or to a storage battery system.

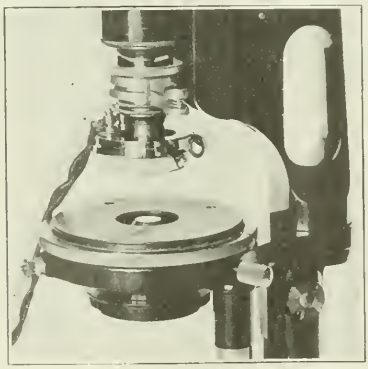


FIG. 2

The new illuminator[1] possesses the advantage that it travels with the microscope tube and is always in position, even though the microscope may be moved about. The lamp possesses the additional advantage that it shows details not visible when vertical illuminators are used. Fig. 3 shows a specimen photographed with a vertical illuminator; Fig. 4 the same photographed with the new illuminator.

Examination of the photomicrographs shows that those portions which are dark by vertical illumination are light in the new prints. This possesses the advantage that for lantern slides one can use the negative directly for comparison with earlier work done with vertical illuminators. The definition of the image obtainable by the new process should result in additional important developments in the field of metallography. It has been employed successfully with a 60-mm. objective for photographic purposes where other forms of illuminators were unsatisfactory and serves well for powers up to 4 mm.

FIG. 1 FIG. 3 FIG. 4

By varying the resistance one can obtain different light intensities for special purposes. By adjusting the position of the lamp almost any desired contrast is possible. The light is steady, so clear images are obtainable. Any one who has used an arc lamp realizes the difficulty experienced in adjusting the light in photomicrography.

The illuminator is so constructed that it can be used with any type of nosepiece or objective, including the new short type. It is only necessary to clamp it to the objective by means of the spring clamp.

The writer's attention has been called to the fact that in vertical illumination the eye is strained by rays passing up and down through the inclined disk and because the observer has to look through this additional obstruction. The light spot due to the source of illumination also causes strain. In the new process the light source surrounds the objective and a soft light travels through the tube in one direction.

School of Chemistry,
University of Pittsburgh.

*Professor of General and Physical Chemistry University of Pittsburgh.

[1]Patents applied for.

Muscle Shoals Dam Authorized.—An order has been signed by President Wilson authorizing the construction of a water-power dam at Muscle Shoals which will form a part of the government's nitrogen fixation plants and will cost $50,000,000. The Alabama Power Co. gave the government the dam site without cost.

Improvement in Sintering Blast Furnace Flue-Dust

A NEW and improved design of the Dwight and Lloyd sintering machine, which is shown in the accompanying photographs, was recently completed for the Carnegie Steel Company, New Castle, Pa., and is to be used there for sintering blast-furnace flue-dust. This new machine has an active grate surface 42 in. wide and 57 ft. 4 in. long and a sintering capacity $2\frac{1}{4}$ times that of the present standard Dwight and Lloyd machine.

This new large sintering machine contains a number of important improvements which are the result of the experience gained by the American Ore Reclamation Company in the operation of the many standard Dwight and Lloyd sintering machines which have been installed in plants in the last six years.

The standard Dwight and Lloyd machine heretofore used has an active grate surface 42 in. wide and 25 ft. 6 in. long and the lower strand of pallets rolls by gravity along an inclined track back to the driving sprocket wheels. The much greater length of the new machine makes the use of a gravity return undesirable and the lower strand of pallets is, therefore, positively driven along the lower track by sprocket wheels at the discharge end. These discharge-end sprocket wheels are driven in synchronism with the driving-end sprocket wheels as shown in Fig. 1. This synchronous drive insures that the empty pallets are returned to the driving sprocket wheels at the same rate of speed as that of the pallets on the upper strand.

On this new large machine, sliding friction between the pallets and the wind-box tops is eliminated by carrying the weight of the loaded pallets on wheels running on rails. The pallet wheels are fitted with renewable Shelby steel bushings and have large oil spaces that carry a month's supply of grease. The sprocket-wheel teeth drive against tooth surfaces cast in the frame of the pallet and not against the pallet wheels, thus allowing the pallet wheels to properly perform their rolling function around the curved tracks at the drive end.

All of the gears and the sprocket-wheel teeth on the new machine are made of steel castings. All gears and

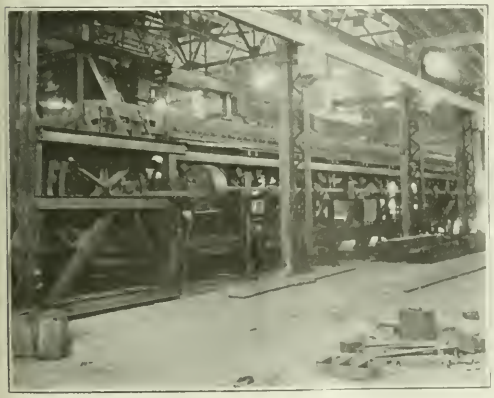


FIG. 1. GENERAL VIEW—PALLETS LOADED WITH PIG IRON FOR TESTING PURPOSES

FIG. 2. DRIVE END

the shaft couplings are wholly enclosed in heavy sheet-steel housings. The sprocket-wheel teeth are removable and are machined in jigs so that they are interchangeable, and when worn may be replaced without tearing down the larger members of the drive. The driving pulley is fitted with a cast-iron break-pin to prevent accidental injury to the driving mechanism.

An important feature of the new machine is the use of seal bars on the pallets which automatically maintain air-tight joints between the pallets and the tops of the wind boxes. These seal bars are made very light, and by their own weight bear on the finished surfaces of the wind-box tops and also fit against the finished sides of the pallet slots in which the bars are hung.

The first one of the new machines was thoroughly tested under full-load conditions, which were obtained by loading the upper strand of pallets with 20 tons of pig iron, as shown in the photograph. In all of the tests the machine ran with a notable degree of smoothness and the seal bars made a tight joint. The horsepower readings taken during the tests show that the various improvements have been fully effective in reducing the driving load.

The fully loaded machine as set up for the test required 12^{3}_{4} hp.

Based on the performance of the smaller machines now in service, the capacity of the new large machine, when sintering various materials, is estimated to be as follows:

	Tons Sinter per 24 hr.
Flue-dust	300 to 350
Pyrites cinder	375 to 450
Magnetic concentrates	450 to 550

Heavy Hauling with a Tractor

Some recent interesting applications of the tractor in industrial plants are shown in the accompanying illustrations. They suggest many other possible similar uses. Fig. 1 shows a tractor on transfer-buggy work at the Lake Erie Iron Company, Cleveland, Ohio. Fig. 2 shows an engine base casting weighing 2500 lb. on the way from the foundry to the machine shop. Fig. 3 shows 20,000 lb. of steel filings and turnings being moved by the tractor, which is on steel floor plates at the Van Dorn Iron Works, Cleveland, Ohio.

FIG. 1. TRANSFER BUGGY WORK. LAKE ERIE IRON CO., CLEVELAND

FIG. 2. ENGINE BASE CASTING ON WAY FROM FOUNDRY TO MACHINE SHOP. WEIGHT ABOUT 2500 LB.

FIG. 3. 20,000 LB. STEEL FILINGS AND TURNINGS; TRACTOR ON STEEL FLOOR PLATES PUSHING TRANSFER BUGGY. VAN DORN IRON MILLS, CLEVELAND

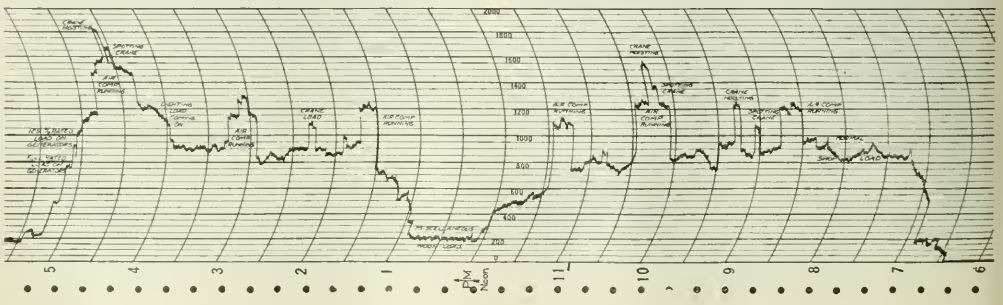
The tractors were made by the Cleveland Tractor Company, Cleveland, Ohio.

Value of Graphic Records in Management

The accompanying record is a representative piece from an instrument installed in a manufacturing plant by the Esterline Co. of Indianapolis. It shows the value of graphic records.

The company generates its own electricity for light and power. The steady plant load has grown until it is a full and efficient load for the boilers and the two generating sets installed. In addition they have several pieces of heavy equipment, operated only occasionally, which throw an excessive and damaging overload on the power plant. Hence the plans for a new addition to the plant.

The record from the graphic instrument, picturing the output of the plant at all hours of the day, showed that while the peak loads thrown on the plant



were greatly in excess of its capacity, they are of short duration, and measured in kilowatt-hours do not call for sufficient energy to warrant the installation of additional equipment. Actual figures showed that the company would make money by carrying the steady load on their power plant, and purchasing the peaks from the local power company.

Personal

Mr. H. A. BRASSERT, who has been connected with the U. S. Steel Corporation since its organization, has resigned his position as assistant general superintendent of the Illinois Steel Co. at South Chicago in order to devote himself to his personal interests. As vice-president of the Miami Metals Co. and subsidiary companies he will have charge of their operations in the production of ferromanganese. Mr. Brassert will also act as consulting engineer for Freyn and Company, engineers and contractors. He will associate himself with Messrs. Francis H. Hardy and Chester D. Tripp, in the firm of Brassert, Hardy & Tripp, to act in a consulting and advisory capacity on commercial and operating problems in the iron and steel and affiliated industries. Mr. Brassert will remain in Chicago, with offices in the Peoples Gas Building.

Mr. H. P. CURTISS has been appointed New England representative for the Clarage Fan Company, Kalamazoo, Mich., with offices at 120 Milk Street, Boston.

Dr. W. F. FARAGHER has resigned his position as research chemist for the Alden Speare's Sons Co. to become Senior Fellow at the Mellon Institute in Pittsburgh. He will work on crude petroleum.

Mr. LEON O. HART has been elected treasurer and a director of the Driver-Harris Co., Harrison, N. J. Mr. Hart has been with the company since 1908 and since March, 1917, has been assistant treasurer.

Mr. HENRY C. HOWARD, JR., treasurer and chief chemist, Charles A. Newhall Co., Inc., Seattle, Wash., has joined the 30th Engineers and is now stationed at Fort Myer, Va. Mr. Howard has specialized in electrochemistry and had recently developed a process for the manufacturing of potassium per-chlorate, the potassium salts being derived from kelp. The process is now being operated on a commercial scale in Seattle.

Dr. I. F. LAUCKS, formerly of Falkenburg & Laucks (dissolved), has opened his new laboratory in Seattle. This laboratory will specialize in the examination of materials of commerce originating in this territory and passing through the port of Puget Sound. The commerce of this port has increased so rapidly in the last few years as to justify the establishment of such a laboratory. A fully equipped metallurgical laboratory is also maintained.

Recent changes have been made in the staff of the Ohio & Colorado Smelting & Refining Co., at Salida, Colo., as follows: E. H. LAWS has resigned as superintendent; A. T. THOMPSON has been appointed superintendent; E. J. BRUDERLIN, assistant superintendent; W. H. NANCE, superintendent of roasting department; J. H. FINGER, chief chemist.

Dr. E. H. LESLIE has resigned from his position as chief chemist of the General Petroleum Corporation of Los Angeles and has assumed new duties as technical adviser to the sales department of the U. S. Industrial Alcohol Company and the U. S. Industrial Chemical Company. He will be located in their main offices at 27 William Street, New York City.

Mr. LOYALL A. OSBORNE of New York, vice-president of the Westinghouse Electric & Manufacturing Company and Chairman of the Executive Committee of the National Industrial Conference Board, has been appointed, by the Secretary of Labor, a member of a committee on industrial peace during the war.

This committee, which consists of five representatives of employers, five labor leaders, and two public men, will provide a definite labor program in order that there may be industrial peace during the war, thus preventing interruption of industrial production vital to the war.

The Worthington Pump and Machinery Corporation has made a number of appointments in its staff, effective March 1, as follows: JAMES E. SAGUE, vice-president, in charge of engineering and manufacturing; LEON P. FEUSTMAN, vice-president, in charge of general commercial affairs, including contracts, prices, purchases, traffic, etc.; FRANK H. JONES, vice-president, in charge of sales; WILLIAM GOODMAN, assistant to vice-president; WILLIAM SCHWANHAUSSER, chief engineer; EDWARD T. FISHWICK, general sales manager; CHARLES E. WILSON, assistant general sales manager. The offices of the above will be at 115 Broadway, New York. NEIL C. LAMONT, works manager, Laidlaw Works, with offices at the works, Elmwood Place, Cincinnati, Ohio.

Mr. E. GYBBON SPILSBURY left New York on Feb. 24 for Cuba and expects to be absent about six weeks. The offices of the E. G. Spilsbury Engineering Co. have been moved from 45 Broadway to 29 Broadway, New York.

Mr. POPE YEATMAN has been placed in charge of the nonferrous metals department of the Raw Materials Division of the War Industries Board, succeeding Eugene Meyer, Jr. Mr. Meyer remains a member of the Raw Materials Division, but for the present is engaged on special work for the Secretary of War.

Book Reviews

STANDARD TABLE OF ELECTROCHEMICAL EQUIVALENTS AND THEIR DERIVATIVES, WITH EXPLANATORY TEXT. By *Carl Hering* and *F. H. Getman*. Duodecimo. 130 pages. Leather binding. Price, $2.00. New York: D. Van Nostrand Company.

The tables are based on 96,494 coulombs as the value of the Faraday, and on the atomic weight of oxygen 16. They give for each element, for its usual valence, or for its more usual valences if it has several, the milligrams per coulomb, coulombs per milligram, grams per ampere-hour, ampere-hours per gram, pounds per 1000 ampere-hours, and ampere-hours per pound. For elements which frequently change their valence in electrolysis, these data are also given for a change of valence of unity. These tables are very carefully calculated, and the figures are probably the most reliable now in print. Dr. J. W. Richards contributes a supplementary tabulation of the valences of the elements in their various combinations, as bases and acids; the values given are the practical or apparent valences, irrespective of any interpretation involving structural formulas. The term "non-valent" is used for elements forming no known combinations; valence zero is reserved for all free elements, not in combination, as is logically required by Faraday's Law.

The remainder of Part I deals with illustrations of calculations based on the electrochemical equivalents. They are carefully explained, and will teach the reader much fundamental electrochemistry. The chemical terms are here at times used loosely (*e.g.*, the *atomic* weight of SO, is spoken of), and the chemistry involved in explaining the electrolysis of 2 Cu Cl to form Cu and Cu Cl, is decidedly vague: it is certainly wrong even to suggest that one of the two molecules of Cu Cl is changed to Cu Cl, at each electrode.

Part II consists of 35 pages of explanation of electrolysis, and a short statement of the electronic theory. Some of the statements in this part are too general (*e.g.*, "Fused salts form practically the only exception to the rule that pure chemical compounds are non-conductors of electricity" —this ignores the conducting oxides, sulphides, etc., and all the pure materials conducting at high temperature, such as Mg O, etc.). The term "electrolyte" is used very vaguely, sometimes for the undissolved solid salt, sometimes for the salt in solution, sometimes (correctly) for the solution, and once for the solvent. Greater precision in this regard is certainly desirable.

Two appendices, written by Dr. Hering, deal with "Valence" and "Elementary Principles of Chemical Reactions and Calculations." The handling of + and — valences at

anode and cathode is carefully worked out, and is worthy of the attention of chemical philosophers; the system should be adopted, for it is clear and logical. Electrolytically, the elements as they are set free from combination by the reducing effect of the current at the cathode or its adducing effect at the anode, must be regarded as having their valences reduced or adduced to zero, in each case. This conclusion is a categorical imperative. The authors deserve our thanks for the time and effort they have put on what is certainly a useful book.

* * *

REPORT OF THE ROYAL ONTARIO NICKEL COMMISSION. With Appendix. Octavo (15 x 24 cm.), xlviii + 646 + 218 (appendix) pages. Printed by order of the Legislative Assembly of Ontario. Toronto, 1917.

The commissioners producing this report were G. T. Holloway of the Royal College of Science, London, and vice-president of the Institution of Mining and Metallurgy; W. G. Miller, provincial geologist of Ontario; McGregor Young of Toronto, and T. W. Gibson, Deputy Minister of Mines, Toronto. We name these gentlemen because they have done a splendid piece of work and deserve personally the thanks of the metallurgical fraternity as well as the gratitude of the Canadian government.

The first 48 pages are a summary and conclusions. The two principal questions to be determined were: (1) Can nickel be economically refined in Ontario? (2) Are the nickel deposits of Ontario of such a character that this Province can compete successfully as a nickel producer with any other country? The commissioners had no hesitation in answering both these questions in the affirmative. Their studies, however, on which these conclusions were based, and which are set forth *in extenso* in their report, embraced (a) The occurrence, deposit, supply, mining, products, by-products and alloys of nickel in Ontario and elsewhere, together with the present, probable and possible uses thereof. (b) The smelting, refining, manufacture and treatment of nickel, its ores, products, by-products and alloys, in Ontario and elsewhere. (c) The demand and market for nickel, its ores and products, by-products and alloys. (d) The probable development and requirements of the nickel and allied industries in Ontario. (e) Suggestions upon a just system of taxation of nickel lands, ores, products and industries in Ontario.

A further review of the book is unnecessary: we need only to state that the commissioners have actually fulfilled this amazing program, and have done it handsomely. All the previous treatises on nickel put together do not contain as much valuable information concerning this subject. It is absolutely comprehensive and complete. (For instance, 56 pages of Bibliography of Nickel.) We congratulate them sincerely on their fine work.

As a practical question it remains to state how the report is distributed.

Current Market Reports

The Iron and Steel Market

Traffic conditions, as affecting the iron and steel industry's operations, have continued to improve, but there is no chance of March making a new record for production as it frequently does. The railroads can clear their congestion and resume normal operations, only slowly, while apart from that is the fact that the exigencies of war, and particularly our share in provisioning our Allies, requires much special movement of freight, interfering with ordinary traffic movement. In particular the movement of foodstuffs from Chicago and other far interior points to seaboard has in the past few weeks tied up a great deal of transportation capacity.

Pig iron production in the fore part of March was at the rate of about 33,000,000 tons a year, while the productive capacity is at least 43,000,000 tons. The restriction in output was wholly by reason of insufficient coke supplies. The by-product ovens at blast furnaces have not been fully supplied with coal, although their supplies have probably been 90 per cent., against 75 per cent or less in January, when the worst conditions obtained. In various districts there has been a shortage of beehive coke owing to insufficient movement, and this influence has been most pronounced in the case of Connellsville. In February Connellsville coke shipments rose to a rate of nearly 300,000 net tons a week, but the requirements of the furnaces regularly tributary to the region are fully 375,000 tons a week. On the assumption that pig iron production is 10,000,000 tons a year under capacity, the shortage of Connellsville coke accounts for about two-fifths of the total restriction.

There is no shortage of pig iron and there has been none since early in the year, the condition being quite different from that obtaining in 1917, when at practically all times the operation of steel works was restricted by an insufficiency of pig iron. The only reason the light supply of pig iron cannot be regarded as representing a shortage is that the steel mills are greatly restricted in shipping their finished product. The shortage of cars continues, while few of the embargoes have been removed, and railroad permits, to ship into or through embargoes, are not granted with much more freedom than formerly. The steel mills shipped finished products in January at the rate of about 60 per cent of capacity. February showed an average rate of about 65 per cent, and at the middle of March shipments are averaging 70 per cent or a trifle more. Meanwhile there is a little accumulation of pig iron, also a little accumulation of ingots. Production of finished steel is slightly less, on an average, than the shipments, as the mills are making an effort to reduce stocks, which at many mills are an encumbrance.

Commercial Demand

As to any appraisal of the market situation and prospects a serious obstacle is the fact that trade currents and influences, usually an object of close scrutiny, cannot be observed at this time. Buyers have a large tonnage on mill books, much of the tonnage long overdue, and this would naturally make them indisposed to make additional purchases. Uncertainty as to prices causes an indisposition to buy for far forward deliveries and thus the volume of buying does not furnish the usual market index. The willingness of many buyers to accept shipments cannot be tested because they are embargoed. Technically the position is that the mill cannot ship by reason of traffic conditions, but one does not know that if traffic conditions were suddenly made normal the consumers would continuously accept the larger shipments that would then be made. Many consumers, perhaps, are hiding behind embargoes and not disclosing their real situation as to the amount of steel they need.

Appearances, so far as they can be observed, are that the strictly commercial demand for steel is extremely limited. Ordinary commercial work is largely suspended. Quite a distorted view may be obtained, however, by observing merely that requirements for steel entirely dissociated from prosecution of the war promise to be very light, because one activity after another transfers itself from the commercial class to the war class. The largest single customer of the steel industry are the railroads, but the buying of railroad material is now a government activity, and large orders are to be placed. Oil development and transport, normally consuming a great deal of steel, is now regarded as a war activity, and so with coal mine equipment and a host of things.

Steel for war has fallen broadly into two categories, the steel that is needed only once, for certain descriptions of equipment, and the steel that will be needed in a steady stream while the war lasts. In the former class, for instance, is steel for building and equipping army cantonments and shipyards, while in the latter class is steel for guns, shells and ships. Demands in the former class are playing out, while demands in the latter are increasing.

On the whole there is very considerable reason for doubting whether there will be enough demand for steel to enable the industry to operate at 85 or 90 per cent of its capacity. As long as traffic conditions prevent the industry from operating at the rate desired the extent of the requirements is not disclosed. At capacity, the steel industry can produce approximately 3,000,000 gross tons of finished rolled steel a month. With fair traffic conditions, but with some labor shortage and troubles of other descriptions, it ought

to be able to produce 2,500,000 tons a month without much difficulty. It is quite impossible to make up any budget of war and near-war requirements in steel that will total any such tonnage, but this is all theory, and the practical operation of the market in the next few weeks will probably make some definite disclosures.

The present set prices for iron and steel, extended in their operation to March 31 by the announcement of December 28, will probably be reaffirmed by the War Industries Board, either to the end of the year, as desired by the producers, or for an indefinite period. At a meeting of representative manufacturers held in New York Friday, March 1, the matter of conferring with the War Industries Board was left to the Institute committee, without specific instructions. Some interests would prefer slight modifications in the schedule, but the preponderating sentiment is that the schedule is a fairly well balanced one, and as it is reasonably well known that the War Industries Board would be indisposed to advance any prices the trade's natural preference is that no change should be made. It is important to observe that the strategic position of the War Industries Board is quite different from the one it occupied last summer when it sought a voluntary agreement with the producers. At that time ordinary commercial demand was considered an important factor, and this had to be considered when the government had no legal authority as to prices except in the case of its own purchases. At the present time the government purchases greatly preponderate, and at any time the government could set prices, with full legal authority, on this class of business. The result of the situation is that the War Industries Board occupies a very strong position.

Chemical Market

Coal Tar Products.—While the inquiry was slightly improved, there was not a great deal of business passing during the interval. The scarcity of some of the important products on the list has resulted in an advance in prices on several items.

Benzol.—The demand has improved slightly and, while there is a little more business passing than during the past few months, the movement continues below normal, with prices unchanged.

Phenol.—Offerings were light, but the demand is in like order, and prices are slightly firmer.

Toluol.—The Government is not permitting the release of any large quantities of material; second hands, however, are offering small quantities and are exacting high prices.

Naphthalene.—The inquiry has improved considerably of late, with prices higher and the supply considerably below normal.

Aniline Oil.—Prices hold steady, although the demand of late has fallen off somewhat.

Beta Naphthol.—Has been fairly active, but the production is sufficient to cover requirements of the trade, and prices are unchanged.

Dimethylaniline.—Has been advanced in price and some producers are offering only on contract.

Ortho Nitro Toluol.—The scarcity of toluol coupled with an increase in the buying inquiry has caused leading producers to advance prices.

Para Nitro Toluol.—The demand is not heavy and, despite the fact that raw material is scarce, prices are unchanged.

Benzaldehyde.—The scarcity of raw material has resulted in the restriction of production, and prices are advanced, with only a few producers offering.

Benzoate of Soda.—Remains in speculative hands and prices are fluctuating in a nervous way according to ideas of holders based on the demand.

Heavy Chemicals.—The general trend of values under this heading has been downward during the past two weeks, due principally to the lack of actual consuming demand and the difficulty of securing export licenses and the resulting curtailment of trade.

Caustic Soda.—A marked decline on caustic values has been noted during the past two weeks, and sales have occurred as low as 4.25c. for material from New York store. The production continues on a large scale and, due to the impossibility of exporting the usual amounts, the domestic output at the moment is probably two or three times in excess of the domestic production. For shipment from works there have been special sales at 4c., works, but this figure is low and fractional advances have been quoted for distant delivery. There has been but a very limited inquiry for distant deliveries.

Soda Ash.—The movement has been unimportant, and prices are on about the same level as when we last reported. There has been some inquiry for export barrels and for dense ash, but the inquiry has been from comparatively few sources.

Copper Sulphate.—The market has improved under a better inquiry and there have been sales of Nichols brand at 9⅜c. and 9½c. The outside brands have been selling at prices ranging from 9c. to 9¼c.

Cyanide of Soda.—A weak market continues, and there have been offerings as low as 36c., although the general trade is asking 42c. and 45c. An increased output has been the cause of the lower situation.

Yellow Prussiate of Potash.—Offerings have been more liberal, and there have been important sales as low as $1.22, although $1.25 is more generally quoted. The buying season for prussiates is now approaching and improvement is looked for. Red prussiate has been offered at $2.80 to $2.90.

Prussiate of Soda.—Important business has passed at 37½c., and there are sellers now at 38½c. and 39c.

Chlorate of Potash.—An extremely dull situation has prevailed and the product has been difficult to move for either export or domestic account. It is reported that there have been offers as low as 28c., although this was an export lot for which a license could not be secured. Sales, however, of ordinary amounts have occurred at 34c. for crystals ground free of charge.

Bleaching Powder.—A lack of demand has prevailed and there have been offers of material from store at prices ranging from $1.85 to $2.00. From works, however, makers quote $2.25.

Bichromate of Soda.—The buying flurry has continuedl and there have been a number of important sales at prices ranging from 23c. to 24c. at various points. The production has been well sold and the product has passed into second hands.

Glycerin.—Sales during the last ten days have probably totaled close to 200 cars of dynamite at prices ranging from 65½c. to 66½c. The explosives manufacturers have entered the market in a big way and at the moment of writing are still bidding at 66c. with refiners holding at 68c.

Acetic Acid.—Stocks have dwindled and there are very few offers reported, particularly on the lower tests. The 28 per cent material has been sold at 6½c. Chicago, but at the moment of writing sellers are asking 8½c. rolling. Glacial acid is offered at 37c., carboys extra.

Sulphuric Acid.—The movement has been much relieved and tank cars have been coming through more satisfactorily. While considerable business was done early in the interval at $90.00, drums included, f.a.s., there are offers now of the 66 degree brimstone material at $75, drums inclusive, f.a.s. In seller's tanks there are offers at $40.00, seller's tanks, seller's works. Some 60 degree acid has been offered at $23.00, buyer's tanks, seller's works.

Arsenic.—The Food Administration has fixed a price of 9½c. at which white arsenic should be sold. As a consequence of this situation the trade is much unsettled as they are somewhat uncertain as to the desires of the Administration. Most of the trade have withdrawn offers but some material is available at 17¼c.

Aqua Ammonia.—Supplies have been almost eliminated from the market. Despite the fact that the Government has fixed a price of 8½c. for the 26 degree material there has been some trading of a few drums practically daily at prices ranging from 19c. to 23c.

Non-Ferrous Metal Market

Monday, March 11.—There have been no startling developments in these markets. Tin continues to be very scarce for prompt supplies and futures have again advanced.

Copper.—Consumers experienced little difficulty in obtaining adequate supplies during the month of February and there seems to be enough copper for present needs. The refineries are watching the labor situation very closely and

are experiencing some difficulty in holding men owing to higher wages being offered elsewhere. There is a belief that a higher price will be recommended for copper in June when the subject comes up for discussion again. Some of the smaller producers are unable to make a profit at present prices. The price for all grades continues at 23.50 for producers and 24.67½ for jobbers.

Tin.—In February 1280 tons of tin arrived at Atlantic ports and on March 1, only 197 tons was in stock at Atlantic ports. At Pacific ports the arrivals for February were 1548 tons. Total deliveries were 3398 tons. No Straits tin is offered for shipment before June. Banca tin is available at 75 cents for March shipment and 74.50 for April. English, Lamb & Flag is held at 81.50 for March shipment. A little 99 per cent tin is offered on spot at 84 cents.

The monthly statistics compiled by the New York Metal Exchange are interesting and are given as follows:

Tons of 2240 lb.

Straits			
Shipments during	Feb., 1918.	Jan., 1918.	Feb., 1917.
To Great Britain	*1,000	*1,500	4,264
To Continent	* 500	* 500	943
To United States	*3,500	*2,500	1,048
Total from Straits.....	*5,000	*4,500	6,255
Consumption:			
London deliveries	1,595	1,579	1,117
Holland deliveries	.....	71	85
United States	3,398	4,642	3,930
Total	4,993	6,292	5,132
Stocks at close of month:			
In London—			
Straits, Australia	2,703	3,499	2,927
Other kinds	482	498	995
In Holland	.....	.....	.....
In United States	197	767	3,027
Total	3,382	4,764	6,949
Afloat—			
London	*3,370	*4,085	6,444
Banka & Billiton	*3,200	*2,600	2,018
United States	*7,082	*5,500	4,216
Total afloat close of month	*13,652	*12,185	12,678
	Feb. 28,	Jan. 31,	Feb. 28,
Total visible supply	1918. 17,034	1919. 16,949	1917. 19,627

* Estimated.

Lead.—The Trust price of lead was again raised $5 per ton to 7¼ cents on Feb. 26. The market at the time of writing was dull and the premium for prompt metal had disappeared in the West. Independents are asking 7⅝ to 7½ cents.

Spelter.—There has been a fair demand for spot spelter and sales have been made as high as 8¼ cents New York. At Western points the price has been as low as 7½ cents.

Aluminium.—The President has approved an agreement made between the War Industries Board and the producers of aluminium fixing the price of aluminium at 32 cents per lb. in 50 ton lots f.o.b. shipping point, 98 to 99 per cent material. The conditions of the agreement are: First, that the producers will not reduce the wages now being paid; second, that they will sell to the allies, to the public, and to the Government at the same price; third, that they will take the necessary measures, under the direction of the War Industries Board, for the distribution of the aluminium to prevent it from falling into the hands of speculators, who might increase the price to the public; and, fourth, that they pledge themselves to exert every effort necessary to keep up the production of aluminium so as to insure an adequate supply so long as the war lasts.

Radium.—The price of radium is understood to be in the neighborhood of $2,800,000 per oz. at present. Before the war it sold at $1,000,000 per oz., although it was produced at a considerably lower figure, but not for sale, by the Bureau of Mines in their experimental plant in Colorado.

OTHER METALS

Aluminium, lb., 98-99 per cent, virgin, Gov't price	.32
Bismuth, lb.	2.50–2.75
Cadmium, lb.	1.50
Nickel, electrolytic, lb.	55.50
Silver, oz.	.85⅝
Platinum, oz.	108.00
Palladium, oz.	135.00–137.00
Cobalt, lb.	3.25–3.50
Magnesium, lb.	2.00
Quicksilver, Cal.	125.00
Quicksilver, Mexican	115.00

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, FEB. 21, 1918

Acetic anhydride	lb.	1.35 — 1.50
Acetone, drums	lb.	Nominal
Acid, acetic, 28 per cent	lb.	.08½— .09
Acetic, 56 per cent	lb.	Nominal
Acetic, glacial, 99½ per cent, carboys	lb.	.37 — .38
Boric, crystals	lb.	.13½— .14¼
Citric, crystals	lb.	.74½— .75
Hydrochloric, C. P.	lb.	.08 — .08½
Hydrochloric, 20 deg.	lb	.02½— .03
Hydrochloric, conc., 22 deg.	lb.	.03 — .03½
Hydrofluoric, 30 per cent, in barrels	lb.	.06 — .06¼
Lactic, 44 per cent	lb.	.15 — .15½
Lactic, 22 per cent	lb.	.05½— .06½
Nitric, 36 deg.	lb.	Nominal
Nitric, 42 deg.	lb.	.09½— .09½
Oxalic, crystals	lb.	.44 — .45
Phosphoric, 47-50 per cent crude	lb.	.07½— .10
Phosphoric, ref. 50 per cent	lb.	.26 — ...
Picric	lb.	Nominal
Pyrocatlic, resublimed	lb.	3.10 — 3.15
Sulphuric, 60 deg.	ton	... — 35.00
Sulphuric, 66 deg.	ton	40.00 — 45.00
Sulphuric, oleum (Fuming), tank cars	ton	77.00 — 80.00
Tannic, U. S. P., bulk	lb.	1.30 — 1.35
Tartaric, crystals	lb.	.75 — .78
Tungstic, per lb. of W	lb.	1.80 — 1.90
Alcohol, sugar cane, 188 proof	gal.	4.93 — 4.95
Alcohol, wood, 95 per cent	gal.	1.35 — 1.38
Alcohol, denatured, 180 proof	gal.	.70 — .72
Alum, ammonia lump	lb.	.04 — .04¼
Alum, chrome ammonium	lb.	.18½— .19
Alum, chrome potassium	lb.	.20½— .22
Alum, chrome sodium	lb.	.12½— .13
Alum, potash lump	lb.	.08¼— .09½
Aluminium sulphate, technical	lb.	.01¾— .02½
Aluminium sulphate, iron free	lb.	.02¾— .03¼
Ammonia aqua, 26 deg. carboys	lb.	.24 — .25
Ammonia, anhydrous	lb.	Nominal
Ammonium carbonate	lb.	.11 — .12
Ammonium nitrate	lb.	(Fixed price) .14
Ammonium, sulphate domestic	lb.	.07½— .07¾
Amyl acetate	gal.	5.00 — 5.25
Arsenic, white	lb.	.17¼— .17½
Arsenic, red	lb.	.65 — .70
Barium carbonate, 99 per cent	ton	80.00 — 90.00
Barium carbonate, 97-98 per cent	ton	65.00 — 67.00
Barium chloride	ton	65.00 — 85.00
Barium sulphate (Blanc Fixe, powder)	lb.	.03¾— .04
Barium nitrate	lb.	.08½— .08¾
Barium peroxide, basis 70 per cent	lb.	.30 — .32
Bleaching powder, 35 per cent chlorine	lb.	.02 — .02½
Borax, crystals, sacks	lb.	.07¼— .08¼
Brimstone, crude	ton	Nominal
Bromine, technical	lb.	.75 — ...
Calcium, acetate, crude	lb.	Nominal
Calcium, carbide	lb.	.14¼— .14½
Calcium chloride, 70-75 per cent, fused, lump	ton	23.00 — 27.00
Calcium peroxide	lb.	1.60 — 1.70
Calcium phosphate	lb.	.34 — .35
Calcium sulphate 98-99 per cent	lb.	.09 — .09½
Carbon bisulphide	lb.	.08 — .10
Carbon tetrachloride, drums	lb.	.15½— .16
Carbonyl chloride (phosgene)	...	... — ...
Caustic potash, 88-92 per cent	lb.	.84 — .85
Caustic soda, 76 per cent	lb.	.04¼— .04½
Chlorine, liquid	lb.	.15 — .18
Cobalt oxide	lb.	1.60 — 1.65
Copperas	lb.	.01¼— .01½
Copper carbonate	lb.	.30 — .40
Copper cyanide	lb.	.75 — .78
Copper sulphate, 99 per cent, large crystals	lb.	.09½— .09¾
Cream of tartar, crystals	lb.	.59 — .61
Epsom salt, bags	lb.	.03¼— .03½
Formaldehyde, 40 per cent	lb.	.19½— .20
Glauber's salt	100 lb.	1.75 — 2.00
Glycerine, bulk, C. P.	lb.	.68½— .69
Iodine, resublimed	lb.	4.25 — 4.35
Iron oxide	lb.	.13 — .15
Lead, acetate, white crystals	lb.	.17 — .18
Lead arsenate (Paste)	lb.	.15 — .18
Lead nitrate	lb.	.15 — .16
Litharge, American	lb.	.09½— .11½
Lithium carbonate	lb.	1.50 — 2.00
Manganese dioxide, U. S. P.	lb.	.70 — .75
Magnesium carbonate, technical	lb.	.10½— .11
Nickel salt, single	lb.	.12½— .13
Nickel salt, double	lb.	.12 — .14
Phosgene, see Carbonyl chloride	...	... — ...
Phosphorus, red	lb.	1.40 — 1.50
Phosphorus, yellow	lb.	1.55 — 1.60
Potassium bichromate	lb.	.44 — .46
Potassium bromide granular	lb.	1.35 — 1.50
Potassium carbonate calcined, 85-90 per cent	lb.	.95 — 1.05
Potassium chlorate, crystals	lb.	.36 — .40
Potassium cyanide, 98-99 per cent	lb.	2.50 — 2.75
Potassium iodide	lb.	3.75 — 3.80
Potassium muriate 80-85 p. c. basis of 80 p. c.	ton	340.00 — 350.00
Potassium nitrate	lb.	.27 — .31
Potassium permanganate (U. S. P.)	lb.	4.00 — 4.10

Potassium prussiate, red	lb.	2.80 —	2.90
Potassium prussiate, yellow	lb.	1.22 —	1.25
Potassium sulphate, 90-95 p.c. basis 90 p.c.	ton	Nominal	
Rochelle salts	lb.	.39 —	.39½
Salammoniac, gray gran.	lb.	.15½—	.17
Salammoniac, white gran.	lb.	.15 —	.16
Sal soda	100 lb.	1.25 —	1.30
Salt cake	ton	25.00 —	26.00
Silver cyanide, based on market price of silver	oz.	.....	.....
Silver nitrate	oz.	.53¾—	.55
Soda ash, 58 per cent, light, flat	100 lb.	2.80 —	2.90
Soda ash, 58 per cent, dense, flat	100 lb.	3.60 —	4.00
Sodium acetate	lb.	.16½—	.17
Sodium bicarbonate, domestic	lb.	.02⅞—	.03
Sodium bicarbonate, English	lb.	.....	.....
Sodium bichromate	lb.	.23¾—	.24
Sodium bisulphite, powd.	lb.	.08 —	.10
Sodium chlorate	lb.	.22 —	.24
Sodium cyanide	lb.	.36 —	.40
Sodium fluoride, commercial	lb.	.17 —	.18
Sodium hyposulphite	lb.	.02½—	.....
Sodium molybdate, per lb. of Mo	lb.	2.50 —	.....
Sodium nitrate, 95%	100 lb.	4.50 —	4.60
Sodium nitrite	lb.	.35 —	.36
Sodium peroxide	lb.	.45 —	.50
Sodium phosphate	lb.	.03¾—	.04¼
Sodium prussiate, yellow	lb.	.38½—	.40
Sodium silicate, liquid (60 deg.)	lb.	.04½—	.05
Sodium sulphide, 30 per cent., crystals	lb.	.02¾—	.03
Sodium sulphide, 60 per cent., fused	lb.	.04¾—	.05
Sodium sulphite	lb.	.05 —	.06
Strontium nitrate	lb.	.25 —	.35
Sulphur chloride, drums	lb.	.06 —	.06½
Sulphur dioxide, liquid, in cylinders	lb.	.15 —	.40
Sulphur, flowers, sublimed	100 lb.	4.05 —	4.60
Sulphur, roll	100 lb.	3.70 —	3.85
Sulphur, crude	ton	Nominal	
Tin bichloride, 50 deg.	lb.	Nominal	
Tin oxide	lb.	.75 —	.90
Zinc carbonate	lb.	.25 —	.30
Zinc chloride	lb.	.13 —	.16
Zinc cyanide	lb.	Nominal	
Zinc dust, 350 mesh	lb.	.14 —	.16
Zinc oxide, American process XX	lb.	.14 —	.15
Zinc sulphate	lb.	.06 —	.07

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.35 —	.40
Benzol, 90 per cent	gal.	.....	.....
Toluol, pure water white	gal.	Nominal	
Xylol, pure, water white	gal.	.35 —	.50
Solvent naphtha, water white	gal.	.17 —	.22
Solvent naphtha, crude, heavy	gal.	.13 —	.16
Creosote oil, 25 per cent	gal.	.33 —	.35
Dip oil, 20 per cent	gal.	.29 —	.30
Pitch, various grades	ton	8.00 —	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05 —	1.10
Carbolic acid, crude, 50 per cent	lb.	.60 —	.65
Carbolic acid, crude, 25 per cent	lb.	.35 —	.38
Cresol, U. S. P.	lb.	.18 —	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00 —	1.25
Alpha naphthol, distilled	lb.	1.60 —	2.00
Alpha naphthylamine	lb.	.60 —	.62
Aniline oil, drums extra	lb.	.27 —	.28
Aniline salts	lb.	.32 —	.34
Anthracene, 80 per cent	lb.	.50 —	.65
Benzaldehyde (f.f.c.)	lb.	4.75 —	5.50
Benzidine, base	lb.	1.75 —	1.85
Benzidine, sulphate	lb.	1.40 —	1.50
Benzoic acid U. S. P.	lb.	5.25 —	5.50
Benzoate of Soda, U. S. P.	lb.	4.50 —	4.75
Benzyl chloride	lb.	2.25 —	2.50
Beta naphthol benzoate	lb.	10.00 —	12.00
Beta naphthol, sublimed	lb.	.85 —	.90
Beta naphthylamine, sublimed	lb.	2.65 —	.....
Dichlor benzol	lb.	.12 —	.18
Diethylaniline	lb.	4.00 —	5.00
Dinitro benzol	lb.	.35 —	.40
Dinitrochlorbenzol	lb.	.40 —	.42
Dinitronaphthaline	lb.	.55 —	.60
Dinitrotoluol	lb.	.55 —	.60
Dinitrophenol	lb.	.50 —	.55
Dimethylaniline	lb.	.63 —	.65
Diphenylamine	lb.	1.00 —	1.10
H-acid	lb.	2.25 —	2.50
Metaphenylenediamine	lb.	1.85 —	2.00
Monochlorbenzol	lb.	.19 —	.22
Naphthalene, flake	lb.	.10½—	.11
Naphthalene, balls	lb.	.12 —	.14
Naphthionic acid, crude	lb.	1.40 —	1.50
Naphthylamin-di-sulphonic acid	lb.	1.00 —	1.10
Nitro naphthaline	lb.	.45 —	.50
Nitro toluol	lb.	.50 —	.55
Ortho-amidophenol	lb.	.....	.....
Ortho-dichlor-benzol	lb.	.15 —	.18
Ortho-toluidine	lb.	1.25 —	1.30
Ortho-nitro-toluol	lb.	.75 —	1.00
Para-amidophenol, base	lb.	3.50 —	4.00
Para-amido-phenol, H. Cl.	lb.	4.00 —	5.00
Para-dichlor-benzol	lb.	.12 —	.15
Paranitraniline	lb.	1.25 —	1.30
Para-nitro-toluol	lb.	1.50 —	1.60
Paraphenylenediamine	lb.	3.00 —	3.50
Para toluidine	lb.	2.25 —	2.50
Phthalic acid anhydride	lb.	4.50 —	5.00
Phenol, U. S. P.	lb.	.53½—	.55
Resorcin, technical	lb.	6.00 —	7.00
Resorcin, pure	lb.	9.00 —	10.00
Salicylic acid	lb.	1.00 —	1.10
Salol	lb.	1.85 —	2.00
Sulphanilic acid, crude	lb.	.32 —	.35
Toludin	lb.	2.50 —	.....
Toluidine-mixture	lb.	.75 —	.85

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4.00 —	.....
Corning, Ohio	bbl.	2.85 —	.....
Somerset, Ky.	bbl.	2.60 —	.....
Wooster, Ohio	bbl.	2.38 —	.....
Indiana	bbl.	2.08 —	.....
Illinois	bbl.	2.22 —	.....
Oklahoma and Kansas	bbl.	2.00 —	.....
Caddo, La., light	bbl.	2.00 —	.....
Corsicana, Tex., light	bbl.	2.00 —	.....
California	bbl.	.98 —	1.32
Gulf Coast	bbl.	1.00 —	.....
Fuel Oil			
New York	gal.	.11 —	.....
Pittsburgh	gal.	.07½—	.10
Oklahoma-Kans.	bbl.	1.50 —	2.35
Texas	bbl.	1.50 —	1.90
Los Angeles	bbl.	1.52 —	.....
San Francisco	bbl.	1.45 —	.....
Gasoline (Wholesale)			
New York	gal.	.24 —	.....
Boston	gal.	.25 —	.....
Pittsburgh	gal.	.26 —	.....
Chicago	gal.	.21 —	.....
Oklahoma	gal.	.25 —	.....
San Francisco	gal.	.20 —	.....

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.21 —	.22
Cylinder, light	gal.	.36 —	.38
Cylinder, dark	gal.	.35 —	.36
Paraffine, high viscosity	gal.	.40 —	.41
Paraffine, 903 sp. gr.	gal.	.33 —	.34
Paraffine, .865 sp. gr.	gal.	.22 —	.23

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f.o.b. Florida	gal.	.44 —	.....
Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.53 —	.....
Pine oil, destructively distilled	gal.	.49 —	.53
Pine-tar oil, sp. gr., 1.025-1.035	gal.	.35 —	.....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.40 —	.....
Pine oil, light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37 —	.....
Pine oil, heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.26 —	.....
Pine tar, thin, sp. gr. 1.060-1.080	gal.	.30 —	.....
Turpentine, crude, sp. gr. 0.930-1.000	gal.	.40 —	.....
Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990	gal.	.19 —	.....
Hardwood oil, f.o.b. Michigan, sp. gr. 1.00-1.08	gal.	.19 —	.....
Wood creosote, ref. f.o.b. Florida	gal.	.31 —	.....

Vegetable and Other Oils

China wood oil	lb.	.21 —	.22
Cottonseed oil, crude	lb.	.17½—	.18
Linseed oil, raw, cars	gal.	1.40 —	1.42
Peanut oil, crude	gal.	1.37 —	.....
Rosin oil, first run	gal.	.35 —	.....
Rosin oil, fourth run	gal.	.66 —	.....
Soya bean oil, Manchuria	lb.	.18¾—	.19
Turpentine, spirits	gal.	.45 —	.....

Miscellaneous Materials

Barytes, floated, white, foreign	ton	40.00 —	50.00
Barytes, floated, white, domestic	ton	30.00 —	36.00
Beeswax, white, pure	lb.	.58 —	.64
Casein	lb.	.22 —	.30
Chalk, light, precipitated, English	lb.	.....	.....
China clay, imported, lump	ton	17.50 —	36.00
China clay, domestic, lump	ton	12.50 —	20.00
Feldspar	ton	8.00 —	12.00
Fuller's earth, powdered	100 lb.	1.00 —	1.50
Ozokerite, crude, brown	lb.	.65 —	.75
Ozokerite, American, refined, white	lb.	.75 —	1.00
Red lead, dry, carloads	lb.	.10 —	.11¼
Rosin 280 lb.	bbl.	7.50 —	.....
Soapstone	ton	10.00 —	12.50
Talc, American, white	ton	15.00 —	22.00
White lead, dry	lb.	.09 —	.10

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	Nominal	
Chrome cement, Grecian	net ton	Nominal	
Clay brick, 1st quality fireclay	per 1000	50.00 —	55.00
Clay brick, second quality	per 1000	35.00 —	40.00
Magnesite, raw	ton	30.00 —	35.00
Magnesite, calcined	ton	35.00 —	36.00
Magnesite, Grecian, dead burned	net ton	85.00 —	90.00
Magnesia brick, Grecian, 9x4½x2½	net ton	135.00 —	140.00
Silica brick	per 1000	50.00 —	60.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f.o.b. Niagara Falls, N. Y.	ton	160.00 —	.....
Ferrocerium	lb.	18.00 —	.....
Ferrochromium, per lb. of Cr	lb.	.50 —	.....
Ferromanganese, domestic	ton	250.00 —	.....
Ferromanganese, English	ton	325.00 —	.....
Ferromolybdenum, per lb. of Mo	lb.	5.00 —	.....
Ferrosilicon, 75 per cent, f.o.b. N. Y.	ton	.....	.....
Ferrosilicon, 50 per cent, carloads, del., Pittsburgh	ton	170.00 —	195.00
Ferrosilicon, 50 per cent, contract	ton	100.00 —	175.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	2.30 —	2.35
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.00 —	.....
Ferrovanadium, f.o.b. works	lb.	4.00 —	5.00

Ores and Semi-finished Products

Antimony ore, per unit		1.60 —	1.75
Chrome ore, 48 per cent minimum, f.o.b. Cal., per unit	ton	1.50 —	1.60
Chrome ore, 43 per cent and over, New York, per unit	ton	1.50	
Manganese ore, 48 per cent and over, per unit	ton	1.20	
Manganese ore, chemical	ton	80.00 —	100.00
Molybdenite, per lb. of Mo$_2$	lb.	2.10 —	2.15
Tungsten, Scheelite, per unit of WO$_3$	ton	20.00 —	24.00
Tungsten, Wolframite, per unit of WO$_3$	ton	20.00 —	24.00
Uranium oxide, 96%	lb.	3.25 —	3.60
Vanadium pentoxide, 99%	lb.	10.50 —	.....
Pyrites, foreign	unit	.17 —	.17½
Pyrites, domestic	unit	.28 —	.30

INDUSTRIAL

Financial, Construction and Manufacturers' News

New Companies

THE AMERICAN CEELULOZ & CHEMICAL MANUFACTURING COMPANY, Dover, Del. Capital, $25,000,000. To manufacture chemicals and celluloid products. Incorporators: Henry Bigham, New York; Frank C. Welles, New Rochelle; and O. R. Houston, Great Neck Station, N. Y.

THE ATLAS FOUNDRY COMPANY, Newark, N. J. Capital, $125,000. To operate a local plant for the production of iron and brass products.

THE AUDUBON PAPER STOCK COMPANY, Inc., New York. Capital, $10,000. To manufacture paper. Incorporators: Solomon Ash, A. E. Engeman, New York; and William H. Hitchcock, Jersey City, N. J.

THE BEHRE CHEMICAL WORKS, Madison, N. J. Capital, $50,000. To manufacture chemicals and allied products. Incorporators: James Benny, Burgess A. Cruden, and A. S. Doolan, 27 East Eighteenth Street, Bayonne.

THE BIG VEIN LEAD & ZINC COMPANY, Miami, Okla. Capital, $250,000. To mine for lead and zinc. Incorporators: W. A. Dotty, Miami; G. B. Crumbine and J. A. Utterback, Oklahoma City.

THE BLYTHE COTTON OIL COMPANY, Los Angeles, Cal. Capital, $125,000. To operate a plant for the production of cotton seed oil. Incorporators: R. H. McLarn, G. G. and J. V. Blard, A. C. Anderson and Howard Prowse, Los Angeles.

THE BRITISH-AMERICAN METALLURGICAL CORPORATION, New York. Capital, $5,000,000. To engage in the treatment of ores and the production of chemical products. Incorporators: A. W. Britton, S. B. Howard and G. V. Reilly, New York.

THE BURNET TEXAS GRAPHITE COMPANY, Burnet, Tex. Capital, $62,500. To mine for graphite. Incorporators: P. B. McCable, Burnet; W. B. Garrett, Austin; and C. J Price, Topeka, Kan.

THE CALIFORNIA COTTON OIL COMPANY, Los Angeles, Cal. Capital, $100,000. To operate a plant for the production of cotton seed oil. Incorporators: J. P. Conduit, L. F. Martin, Los Angeles; and T. W. McDevitt, Phoenix, Ariz.

THE CLAREMONT MARL PRODUCTS COMPANY. Claremont, Va. Capital, $250,000. To manufacture marl products for fertilizer use. Incorporators: H. J. Arrington, Claremont; and C. D. Gilliam, Richmond.

THE COLE CHEMICAL COMPANY, St. Louis, Mo. Capital, $200,000. To manufacture chemicals and allied products. B. L. Cole is the principal incorporator.

THE CONSOLIDATED ZINC & SMELTING COMPANY, Inc., New York. Capital, $3,000,000. To engage in the mining, milling and concentrating of lead and zinc ores, etc.

THE COOKS FALLS DYE WORKS, Inc., New York. Capital, $30,000. To manufacture dyestuffs, etc. Incorporators: W. and H. and A. Hine, Cedarhurst, Brooklyn.

THE CROTON COLOR & CHEMICAL COMPANY, Croton, New York. Capital, $150,000. To manufacture chemicals and dyestuffs, etc. Incorporators: H. P. Thrig, E. R. Voltmer and F. C. Schmitz, 31 Union Square.

THE DANIEL BOONE MINING COMPANY, Quapaw, Okla. Capital, $150,000. To mine for lead and zinc. Incorporators: C. H Birr, Muskogee; J. E. Jenkins, Springfield, Mo.; and A. Avery, Oronogo, Mo

THE JAMES F. DUFFY CORPORATION, Bronx, N. Y. Capital, $15,000. To manufacture chemicals and lubricant products. Incorporators: J. S. Michtom, H. G. Fenton and J. F. Duffy, 182 White Plains Avenue.

THE DUPLICO MANUFACTURING COMPANY, New Brunswick, N. J. Capital, $100,000. To manufacture carbon paper and kindred specialties. Incorporators: J. H. Helm, I. B. Glueckfield and George R. Morrison, New Brunswick.

THE ELECTRIC STEEL COMPANY OF AMERICA, Dover, Del. Capital, $4,000,000. To manufacture iron, steel and other metals.

THE EXPORT NITRO-PHOSPHO COMPANY, Newark, N. J. Capital, $120,000. To manufacture phosphates and other fertilizers Incorporators: George R. Swain, John I. Sipp and C. Jacobs, Newark.

THE F. & G. CHEMICAL WORKS, Brooklyn, N. Y. Capital, $5,000. To manufacture chemicals. Incorporators: D. Lenkowsky and M. J. and H. Lesser, 277 Pennsylvania Avenue, Brooklyn.

THE FEDERAL SOAP CORPORATION, New York. Capital, $30,000. To manufacture soap products. Incorporators: R. K. Dehler, A. H. Rees and C. W. Harlow, 150 Nassau Street.

THE FLORIDA GLASS COMPANY, Tampa, Fla. Capital, $250,000. To manufacture glass and glassware of various kinds. C. J. Earley, president; Paul T. Davis, secretary.

THE GOODYEAR MINING COMPANY, Winburne, Pa. Capital, $200,000. To engage in a general mining business. Robert H. Somerville is treasurer and principal incorporator.

THE GRAY INDUSTRIAL LABORATORIES, Elizabeth, N. J. Capital, $125,000. To engage in the treatment of chemicals and chemical products. Incorporators: Thomas T. Gray, Frank A. Urner and Frank B. Mason, all of Elizabeth.

HANSEN, OLSEN & COMPANY, New York. Capital, $20,000. To manufacture paints and varnishes, etc. Incorporators: H. J. Hansen, O. Olsen and W. Ferguson, 27 Cedar Street.

THE HEBRON ROLLER MILLS COMPANY, Hebron, N. D. Capital, $10,000. To operate a local rolling mill. Incorporators: Eugene Weigel, Fred Schwenkand V. Ungerecht.

THE HOWE RUBBER COMPANY, Los Angeles, Cal. Capital, $200,000. To manufacture rubber goods. Incorporators: E. A. Sattler, New Brunswick, N. J.; C. A. Mullen, San Francisco; and E. M Reighard, Los Angeles.

THE HUDSON FOUNDRY COMPANY, New York. Capital, $20,000. To operate a local foundry. Incorporators: J. C. Garrett and J. Mittleman, 27 William Street.

THE INDIA PRODUCTS COMPANY, New York. Capital, $30,000. To manufacture chemicals and allied products. Incorporators: E. F. and E. Groeniger and B Bernbaum, 320 Broadway, New York.

THE JOSIAH SMITH PHENYLE COMPANY, Inc., Yonkers, N. Y. Capital, $25,000. To manufacture paints, disinfectants, chemicals, etc. Incorporators: J. R. Roberson, F. M. Roberson and H. Raynes, 368 South Broadway, Yonkers.

THE LIBERTY MACHINE TOOL & DIE COMPANY, Newark, N. J. Capital, $80,000. To manufacture machine tools, dies, etc. Incorporators: Albert W. Wenzel, Charles L. Barrows, Newark; and H M. Bailey, Irvington.

THE LOWER KAHILTNA MINING COMPANY, Inc., New York. Capital, $250,000. To engage in mining and metallurgical operations. Incorporators: H. N. Armstrong, M. S. Mackay and H. Peters, 14 Wall Street, New York.

THE LYNCHBUEG GLASS WORKS, Lynchburg, Va. Capital, $300,000. To manufacture glass and glassware. Incorporators: N D. Eller, D. B. Ryland, Lynchburg.

THE MINERAL RIDGE MANGANESE CORPORATION, Strasburg, Va. Capital, $250,000. To mine for manganese. Incorporators: William B. Shaffer, Nazareth, Pa., and Charles F. Nelson, Strasburg.

THE NATIONAL ANODE COMPANY, Passaic, N. J. Capital, $100,000. To engage in the production of copper castings. Incorporators: Albert R. Bray, G. W. Bray and William F. Rothlisberger, Newark.

THE NUTRO-PEYO CORPORATION, New York. Capital, $50,000. To manufacture chemical prenarations, etc. Incorporators: L. and J. Rueff-Jordan and L. Bughee, 447 Fort Washington Avenue.

THE ORES CONCENTRATION COMPANY, Jersey City, N. J. Capital, $20,000. To engage in the concentration of ores. Incorporators: Ernest S. Hirschberg, Arthur L. Woodland and Paul F. Hauser, Jersey City.

THE PRESTON TRADING COMPANY, Inc., New York. Capital, $50,000. To manufacture paper and wood pulp. Incorporators: H. E. Herman, A. O. Ernst and G. G. Newhouse, 170 West Seventy-fourth Street.

THE REILLY-EDWARD COMPANY, Dover, Del. Capital, $25,000. To manufacture fertilizers. Incorporators: Frank S. Reilly, Baltimore, Md.; and W. T. Edwards, Readville, Va.

THE REPUBLIC OIL & SULPHUR COMPANY, New York. Capital, $2,000,000. To engage in the production of oil, gas, sulphur, etc. Incorporators: R. Eichman and Louis E. Jump, New York.

THE E. N. ROWELL COMPANY, Inc., Batavia, N. Y. Capital, $25,000. To manufacture paper, etc. Incorporators: E. N. Rowell, C. H. Ruprecht, Batavia, and E. G Buell, 368 Broadway, N. Y.

THE SERB PRODUCTS CORPORATION, Wilmington, Del. Capital, $100,000. To manufacture chemicals and sanctuary oils, etc. Incorporators: M. M. Clancy, C. L. Rimlinger and F. A. Armstrong.

THE SHELBY CHEMICAL COMPANY, Dover, Del. Capital, $250,000. To manufacture charcoal and acetate of lime. Incorporators: M. L. Rogers, L. A. Irwin and William G. Singer, Wilmington.

THE SOUTHERN CHEMICAL COMPANY, El Paso, Tex. Capital, $20,000. To engage in the production of saline products. David Russek is the principal incorporator.

STEIN, HALL & COMPANY, New York. Capital, $2,000,000. To manufacture chemicals. Incorporators: W. S. Goldfrank, W. E. Mann and J. C. Guggenheimer, 27 William Street.

THE STIEGLITZ-TRIEBER COMPANY, New York. Capital, $700,000. To engage in the refining and smelting of metals. Incorporators: F. J. Trieber, L. and A. Stieglitz, 228 Pearl Street.

THE UNION CHEMICAL GLASSWARE COMPANY, Bronx, N. Y. Capital, $20,000. To manufacture chemical glassware. Incorporators: J. S. Einshon, D. Buegeleisen and A. L. P. Pollack, 601 West 168th Street.

THE UNITED LEAD & ZINC COMPANY, Oklahoma City, Okla. Capital, $50,000. To mine for lead and zinc. Incorporators: L. B. Grant, R. B. Halliburton and W. C. Brissey.

THE WILLIAMS CHEMICAL CORPORATION, Dover, Del. Capital, $10,000,000. To manufacture chemicals and allied products. Incorporators: William A. Rogers, Philip L. Nieser and Joseph F. Curtin, all of New York.

THE WILLIAM WATERALL & COMPANY, Camden, N. J. Capital, $125,000. To manufacture paints, white lead, etc. Incorporators: Samuel A. Matlack, Thomas G. Hawke and Ernest W. Holdt.

Construction and Operation

Alabama

ASHLAND.—The Sutton Steele & Steele Manufacturing Milling & Mining Company has completed its organization plans, and will install new dry process with dedusting, classifying and concentrating machinery in its plant to have an output of approximately 50 tons of lead and zinc every ten hours. Hugh B. Evans is president and manager.

ASHLAND.—The Graphite Mills, which recently increased their capital from $80,000 to $250,000, is now developing 80 acres of graphite properties, having a capacity of about 200 tons per ten hours. The company has entirely completed the installation of crushing, classifying and concentrating machinery at a cost of about $60,000.

GADSDEN.—G. W. Heber and N. H Sewall are considering plans for the development of about 400 acres of manganese property located four miles from Ivalee.

LINEVILLE.—The Liberty Graphite Company has recently completed the installation of new machinery in its plant to provide for an increase in its capacity to about 150 tons daily. Leo K. Steiner is president.

TRUSSVILLE.—The Birmingham-Trussville Iron Company has completed extensive improvements at its furnace, and is planning to inaugurate operations at an early date.

Arizona

KINGMAN.—The Standard Mineral Company is planning for the early construction of a new 100-ton mill at its property to provide for increased capacity. The company will soon commence on extensive development work, and arrangements have been made for the installation of a large quan-

tity of new machinery, including gas engines, compressors, pumps and machine drills.

KINGMAN.—Walter H. Brown and associates are planning for the immediate construction of a new milling plant on the Golconda Extension.

KINGMAN.—Sitton & Murphy are planning for the immediate development of the old Shipp mine in the Aquarius mountains. This mine was formerly famous as a silver producer, and it is held that the vein is rich in copper.

Arkansas

WARREN.—Fire, on Feb. 26, partially destroyed the plant of the Warren Cotton Oil & Manufacturing Company, with total loss estimated at $125,000. It is said the plant will be immediately rebuilt.

FORT SMITH.—Announcement has been made of the merger of the Ozark Refining Company and the Prospect Oil & Gas Company, to be capitalized at $1,500,000, and known as the Ozark Oil & Refining Company. The new company is planning for extensive development work in the Humboldt, Kan., field, and eight new wells will be sunk as soon as the weather conditions permit. Extensive improvements will be made at the plant of the Ozark Refining Company, including the installation of new machinery to increase the capacity from 300 to 600 barrels, to be increased ultimately to 1500 barrels, the latter work being estimated to cost $40,000.

California

LOS ANGELES.—The American Dye Works, corner Washington Street and Griffith Avenue, has had plans prepared for the construction of a new shop building, about 20 x 100 ft., at 810 East Washington Street.

LOS ANGELES.—The California-Burdett Oxygen Company, Vernon, near Los Angeles, has completed the construction of extensive additions to its plant for the production of oxyacetylene gas.

LOS ANGELES.—The American Cement Products Company, 2348 Long Beach Avenue, manufacturer of steel reinforced-concrete specialties, is planning to equip a section of its plant for the manufacture of pipe, fence posts and kindred products. E. B. Blinn is president.

PILLMORE.—The Ventura Refining Company has completed the construction of a new local plant for the extraction of wax from its lubricating stock. The new plant will be operated as a by-product works.

ETNA.—I. J. Luce of Seattle, Wash., and John M. Tetherow of Grant's Pass, Ore., who recently acquired the Blue Jene gold mine near Etna operated by the Siskiyou Syndicate, have commenced the construction of a large new stamp-mill, and are planning for extensive developments in the property.

MONTEZUMA.—J. C. Heald has commenced alterations and improvements in his mill in the Nashville district, to provide for increased capacity, and it is anticipated that the work will be completed at an early date.

PILOT HILL.—Extensive improvements are being made at the mill which formerly operated on gold ore from the Buzzard mine. New concentrators are also being provided for the treatment of chrome ore from the Pilot Hill and Salmon Falls districts. It is expected that the work will be completed and operation inaugurated at an early date.

BEAUREGARDE.—Plans have been completed for the construction of a large new 150-ton mill at the group of tungsten claims on Pine Creek in the White Mountains, which were recently taken over by new interests. It is also planned to construct a new electric power line. Cooper Shapley is manager.

Colorado

ELDORA.—Rapid progress is being made in the construction of a large new mill at the Huron gold mine, and it is expected that the work will be completed in the near future.

CLIMAX.—The Climax Molybdenum Company is rushing to completion the construction of its new 250-ton mill for the handling of its molybdenum. The company has also made arrangements for housing 185 of its employees. It is a subsidiary of the American Metal Company. J. M. White is manager.

BLACKHAWK.—Robert Wilkinson and associates have completed the organization of the Powers Mining, Milling & Leasing Company, and taken over the Powers mine in the Russell district. The new company is planning for the installation of new machinery, including electric pumps, air-compressors, etc., at the mine, which is said to be one of the best copper producers in Gilpin County.

BRECKENRIDGE.—Plans are under consideration for the construction of a new mill at the Royal Tiger mine. T. A. Brown is superintendent.

CLIMAX.—The Pingrey Mines Company has commenced extensive development of its molybdenum properties in the Black Metal group of claims on the Bartlett Mountain, and plans are now being completed for the construction of a new 500-ton concentration plant. O. A. King is manager.

Delaware

WILMINGTON.—The nineteen-inch mill at the local plant of the Midvale Steel Company was recently severely damaged, with total loss estimated at $75,000. It is said the destroyed plant will be immediately rebuilt.

WILMINGTON.—The Sugar Refining Company is having preliminary plans prepared for the erection of a large new sugar refinery and power house on the Delaware River. The entire project is estimated to cost about $10,000,000.

Florida

TAMPA.—W. M. Brooks, Tampa, and J. B. Porter, Buffalo, N. Y., have recently acquired extensive phosphate properties near Tampa, and are planning for the immediate installation of a large mining plant for development.

Georgia

SAVANNAH.—The Savannah Warehouse & Compress Company is planning for extensive additions to its high-density cotton compress plant, to provide for increased capacity, the entire work being estimated to cost about $200,000. Col. G. Arthur Gordon is president.

Idaho

SAGLE.—The Armstead Mines Company is considering plans for the construction of a large new mill at its properties in Bonner County during the coming spring. H. H. Armstead is president.

Illinois

CHICAGO.—The Standard Steel Castings Company is making rapid progress in the construction of a new one-story plant at Clearing, Ill. The structure will be about 100 x 200 ft., and is estimated to cost $100,000.

CHICAGO.—The American Cocoanut Butter Company, 2531 West Eighteenth Street, has commenced the erection of a new five-story refinery and power house, about 61 x 80 ft., at 2822-26 South Kilbourne Avenue. The new plant is estimated to cost about $60,000.

CHICAGO.—Work has been commenced by the Union Special Machine Company, West Kinzie Street, on the construction of a new three-story and basement plant, about 100 x 100 ft., at 300-14 West Kinzie Street to cost $250,000. The George A. Fuller Company, 140 South Dearborn Street, has the contract for erection.

CHICAGO.—The American Clay Machinery Company is building a new one and two-story plant at Mansfield, Ohio. The structure will be about 120 x 300 ft., and will cost $80,000. The H. A. Peters Company, 19 South La Salle Street, is the contractor.

LOCKPORT.—The Coke Products Manufacturing Company is making rapid progress in the construction of a large new mill for the manufacture of coke products.

Indiana

INDIANAPOLIS.—The Parker Tire & Rubber Company, Merchants' Bank Building, is considering the construction of a new one-story brick, steel and concrete factory building, about 100 x 400 ft., at South Eastern Avenue and Belt Railway.

INDIANAPOLIS.—The plant of the Stenotype Company is being operated to capacity for the manufacture of fuse parts for the government, order for which has recently been received.

MONTEREY.—The Monterey Electric Light & Power Company, recently incorporated with a capital of $60,000, has had plans prepared for the construction of a new one-story electric power plant, about 50 x 125 ft., to cost $50,000.

Kentucky

CLOVERPORT.—Fire recently destroyed a section of the plant of the Standard Oil Company including two tanks containing about 17,000 gal. of gasoline and oil.

Maryland

BALTIMORE.—The Bethlehem Steel Company has made announcement that plans are under consideration for extensions and additions at its Sparrows Point plant.

BALTIMORE.—The Maryland Bolt Works will build a new addition to its plant to provide for increased capacity.

BALTIMORE.—Plans have been filed by the Federal Tin Company, East Barre Street, for the construction of additions to its plant to provide for increased capacity. Contract for erection has been awarded.

EDGEWOOD.—The United States Government has made announcement that approximately 1000 acres of land adjoining the Aberdeen proving grounds have been acquired for the erection of a large new plant to be devoted to the production of poisonous gases.

HAGERSTOWN.—The Western Maryland Railroad Company has awarded a contract for the erection of a new wheel-shop at its local plant.

ANNAPOLIS.—The State Agricultural Line Board is planning for the acquirement of a site now under consideration to provide for the construction of a new limestone crushing plant.

Massachusetts

BOSTON.—Knox & Morse Company, 96 High Street, has recently awarded a contract to Edward B. Smith, Auburn Street Waltham, for the erection of a new chemical shop at 41 Everett Street, Allston, to be one-story, of brick construction.

WORCESTER.—The Peter Wood Dyeing Company has recently taken over the plant and property of the Thibert Manufacturing Company, Millbury, and will use as an extension to its present plant.

Minnesota

MINNEAPOLIS.—The Gas Traction Foundry Company, 2907 Southeast Fourth Street, has recently had plans prepared for the construction of a new one-story addition, about 100 x 300 ft., to its foundry, to cost $70,000. W. L. Alban, Endicott Building, St. Paul, is architect.

STILLWATER.—The Twin City Forge & Foundry Company has recently filed plans for the construction of a new foundry, about 125 x 400 ft., to cost $50,000. Contract for erection has been awarded.

Missouri

ST. LOUIS.—The Kardell Tractor & Truck Company is said to be considering the construction of a new plant at Oldsmar, Fla., for the manufacture of tractors and similar products.

ST. LOUIS.—The Bridge & Beach Manufacturing Company, manufacturer of stoves, ranges, etc., has recently acquired a tract of ten acres at the northeast corner of the intersection of the Belt Line and Union Avenue, as a site for the construction of a new plant.

KANSAS CITY.—The Witte Engine Works, Sixteenth Street, manufacturer of gas engines, etc., will build a new one-story addition to its plant to provide for increased capacity. The structure is estimated to cost $10,000. Contract for erection has been awarded.

SAGINAW.—The Griffith Lead & Zinc Company is planning for extensive development work on its 750-acre tract recently leased from the Saginaw Mining & Leasing Company. Plans are also under consideration for the construction of a new 350-ton concentration plant.

WENTWORTH.—The Wentworth Lead & Zinc Company, recently incorporated with a capital stock of $200,000, has completed its organization plans, and will develop about 40 acres of lead and zinc properties. A new 250-ton mill will be constructed. D. C. Morris is president.

Montana

GREAT FALLS.—The Anaconda Company is considering plans for immediate construction work on a large new plant at its Boston and Montana works, to be devoted to the electrolytic production of ferromanganese, which is essential in the manufacture of steel.

Nevada

YERINGTON.—The Bluestone Mining & Smelting Company is rushing to completion the construction of a large new plant at its local properties, including two 8-ft. Hardinge ball-mills and flotation apparatus, and it is expected that operations will be inaugurated within the next few weeks.

New Jersey

JERSEY CITY.—Fire, on March 2, damaged the plant of the Crew Levick Company, Ravine Road and West Shore Railroad, to the extent of about $10,000.

OLD BRIDGE.—Due to the acute shortage of coal, the Brookfield Glass Company has been compelled to suspend operations until permanent relief is in sight.

HARRISON.—The National Oil Products Company, Essex Street, has awarded a contract for alterations and improvements in its plant to cost about $63,000. The Becker Construction Company, 361 Grove Street, Newark, is the contractor.

RAHWAY.—Fire, on March 4, partially destroyed the plant of the Rahway Chemical Company, Broad Street and Maple Avenue, with total loss estimated at $15,000. Irwin S. Joseph is president.

BUTLER.—A portion of the plant of the Gulf Oil Refining Company was destroyed by fire on Feb. 21, including four tanks containing about 30,000 gal. of oil.

DELAWANNA.—The Worthen & Aldrich Company, operating a large local dye works, will build a new addition to its plant, about 80 x 160 ft., to cost about $250,000. Plans for the structure have been prepared.

PAULSBORO.—Fire, on Feb. 21, destroyed the hexite catalytic house at the Repauno plant of the E. I. du Pont de Nemours Company at Gibbstown, with total loss estimated at about $50,000. It is said the destroyed structure will be immediately rebuilt.

DELANCO.—The Consolidated Paper Tube Company, Philadelphia, Pa., is having plans prepared for the construction of a new two-story and basement brick local plant, about 50 x 80 ft.

New York

NEW YORK.—The American Chemical Products Company, a Delaware incorporation, has filed authorization papers to operate in New York. G. B. McLeod, 23 Liberty Street, is local representative.

GLENDALE, LONG ISLAND.—The James A. McCafferty & Sons Manufacturing Company, 506 Driggs Avenue, Brooklyn, has had plans prepared for the construction of a new one-story metal works addition to its paint manufacturing plant. The structure will be about 30 x 58 ft.

LONG ISLAND CITY.—The Van Iderstine Company is having plans prepared for the erection of a new addition to its tallow manufacturing plant at Newtown Creek. Edward Hahn, Bridge Plaza, Long Island City, is architect.

MARINERS' HARBOR, STATEN ISLAND.—The Proctor & Gamble Manufacturing Company, Cincinnati, Ohio, has had plans prepared for the construction of six new factory buildings at its plant at Port Ivory, to provide for increased capacity. The Ferro-Concrete Construction Company, Richmond and Harriet Streets, Cincinnati, has the contract for erection.

CORTLAND.—The Cortland Specialty Company, manufacturer of chemicals, etc., is having preliminary plans prepared for the reconstruction of the section of its one and two-story plant, about 67 x 177 ft., recently destroyed by fire. C. W. Clark, 9 Charles Street, Cortland, is architect.

TROY.—Operations have been discontinued at the Breaker Island plant of the American Steel & Wire Company, near Troy, and it is said that the property will be sold. The site consists of about 100 acres, adjacent to the tracks of the New York Central Railroad.

FULTON.—The Oswego Falls Pulp & Paper Company, 314 South First Street, has had plans prepared for the erection of a new two-story addition, to provide for increased capacity. The structure is estimated to cost about $20,000.

Ohio

CINCINNATI.—The Newport Rolling Mill Company has acquired property near Lowell Street, and will use it as a site for the construction of a new addition to its plant. J. B. Andrews is president.

CINCINNATI.—The Cincinnati Pulley Machinery Company has taken out a building permit for the erection of a new addition to its plant on East Third Street, to cost about $6,000.

CLEVELAND.—Fire recently partially destroyed the foundry of the Federal Metal Company, 6621 Morgan Avenue, with loss estimated at $20,000.

CLEVELAND.—The Variety Iron & Steel Works has acquired property, about 130 x 156 ft. on Hamilton Avenue, Northeast, near East Thirty-third Street, and is said to be considering the erection of new additions to its plant.

CLEVELAND.—A building permit has been taken out by the American Steel & Wire Company for the construction of a new benzol plant, about 95 x 110 ft., and a new storage plant, 42 x 146 ft., at Campbell Road, Southeast, and the Ohio Canal, to cost $57,000 and $15,000, respectively.

FINDLAY.—The Buckeye Traction Company is having plans prepared for the construction of a new factory building, and will immediately install a new electric converting furnace to be used for steel production. The plant is estimated to cost $50,000.

HAMILTON.—Contract has been awarded by the Hamilton Furnace Company for extensive improvements and additions to its plant in Cokeotto, near Hamilton, including the construction of an ore bridge and car dumper, the entire work to cost about $500,000. Hunkin & Conkey, Cleveland, are the contractors.

LIMA.—The Monarch Machine Company has awarded a contract to the Concrete Steel Construction Company, Lima, for the erection of a new one-story steel and concrete addition to its plant, about 80 x 200 ft.

TOLEDO.—The F. L. Royster Guano Company has acquired seven acres of land on the north side of the Michigan Central Railroad, near the Toledo Disposal plant, and has awarded contracts for the construction of a large new fertilizer works, the main building of which will be 180 x 500 ft., of brick and cement construction. The plant will have a capacity of about 150,000 tons of fertilizer per year, and about 200 hands will be employed for initial operations.

YOUNGSTOWN.—The Liberty Steel Company is making rapid progress in the construction of its new plant near Warren, to be used for the production of tin. The plant comprises three large mill buildings with tin stacks, administration building and auxiliary structures. It is expected that the new plant will be completed and ready for operation by April 1.

Oklahoma

PICHER.—The Bendene Mining Company is considering plans for the construction of a new concentration plant at its lead and zinc properties.

MIAMI.—J. E. Hellams, 217 South Seventh Street, Muskogee, and associates, are planning for the organization of a new company to be capitalized at $100,000 for the purpose of developing lead and zinc properties in the Miami field. A concentration plant is also planned.

QUAPAW.—The Quapaw Mining Company has plans under consideration for the construction of a new mill on its 80-acre lease, near the Lincolnville station, south of Quapaw.

QUAPAW.—The Medical Mining Company is planning for the immediate construction of a new 250-ton mill at its properties west of Quapaw.

Oregon

GRANTS PASS.—W. A. Sharp, Grant's Pass, and L. C. Sharp, Plattsmouth, Neb., have acquired the placer mining property of the Hydraulic Mining Company, Upper Jump-off-Joe Creek, Jackson County. Extensive improvements will be made on the property, including the installation of hydroelectric precipitating value-recovering machinery.

Pennsylvania

BERWYN.—The American Bronze Company has had plans prepared for the construction of a large new foundry building at its plant.

MARCUS HOOK.—The Sun Oil Company has taken bids for the erection of a new two-story brick administration building, about 35 x 47 ft., at its plant.

PHILADELPHIA.—The Tacony Steel Company has recently acquired property at Bleigh and Spring Streets, and Bleigh and Eugene Streets, for a consideration said to be $65,000, and is considering the construction of additions to its plant on the sites.

PHILADELPHIA.—The Pecora Paint Company, Fourth and Sedgley Streets, has acquired the two and three-story factory buildings, at Sedgley and North Penn Railroad, for a consideration of $100,000, to be used as a new manufacturing plant.

PHILADELPHIA.—The E. I. du Pont de Nemours Company has formally taken over the plant of Harrison's, Inc., manufacturer of paints and chemicals, at Thirty-fourth Street and Gray's Ferry Road, by the recording of the necessary deed.

PITTSBURGH.—Officials of the Pittsburgh Testing Laboratory, one of the best known institutions of its kind in the country, have turned over to the United States Government, for the duration of the war, the entire five-story plant, with full equipment of chemical, physical and analytical laboratories, scientific instruments, laboratories for testing cement and apparatus for inspecting and testing steel. George H. Clapp is president.

Rhode Island

PROVIDENCE.—The Nicholson File Company, Acorn Street, has commenced the construction of three new additions to its plant on Kinsley Avenue.

Tennessee

CENTERVILLE.—The Tennessee-Illinois Phosphate Company, recently incorporated with a capital of $200,000, has acquired about 300 acres of land and is planning for the construction of a plant for mining, milling and refining phosphate.

KNOXVILLE.—The Tennessee Manganese Company has filed notice of an increase in its capital from $20,000 to $200,000, to provide for extensive improvements in its mining facilities, and the construction of a new electric steel furnace to cost about $100,000. The new furnace will have a capacity of 25 tons of manganese daily for initial operations.

MEMPHIS.—Fire, on February 26, damaged the plant of the Webster-Warnock Chemical Company, Union Street, to the extent of $25,000.

Texas

GREENVILLE.—The North Texas Oil & Refining Company is planning for the immediate construction of a large refinery on a site at the junction of the Mineola branch of the M. K. Railway with the Texas Midland Railway, to cost about $250,000. The plant will have a daily capacity of 5000 barrels.

Utah

EUREKA.—Plans are under way for the organization of a company to be known as the Majestic Copper Mining Company, with capitalization of $1,000,000, for the development of a large tract of land in the Erickson district, west of Eureka. Harry Webber, Jr., New York, is interested in the company.

Virginia

NORFOLK.—The Norfolk Glass Manufacturing Company, recently incorporated with a capital of $250,000, has acquired ten acres of land near the junction of the Norfolk Southern and the Virginia Railways, and is planning for the immediate construction of a large plant for the manufacture of glass and glassware. About 300 hands will be employed.

Wisconsin

PLATTEVILLE.—Fire at the plant of the White Rose mine, one of the Gus E. Brown properties, entailed a loss of about $15,000. The destroyed section will be immediately rebuilt.

PLATTEVILLE.—The Wisconsin Zinc Company has completed the construction of a new 500-ton mining and milling plant at its Copeland mine in the Shullsburg district.

MILWAUKEE.—The Milwaukee Paper Box Company, 400 Florida Street, has had plans prepared for the erection of a new five-story and basement factory, about 100 x 150 feet, at South Pierce Street and Muskegon Avenue. The estimated cost of the structure is $150,000.

HALIFAX.—The plant of the Martin Sembur Paint Company was recently partially destroyed by fire, with total loss estimated at $70,000.

New Publications

TESTS OF OXY-ACETYLENE WELDED JOINTS IN STEEL PLATES. By Herbert F. Moore. Bulletin No. 98 of University of Illinois, Experiment Station, published by the University, Urbana, Ill.

MANGANESE AND CHROMIUM. By E. S. Boalich. Preliminary report of the California State Mining Bureau, Ferry Building, San Francisco.

COST-ACCOUNTING FOR OIL PRODUCERS. By Clarence G. Smith. Bulletin No. 158, Bureau of Mines. Obtainable from the bureau at Washington, D. C.

BIENNIAL REPORT OF THE STATE GEOLOGIST 1915-1916. Issued by the North Carolina Geological and Economic Survey.

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Unwavering Purpose

THERE comes a time in every fight for principle when the critical factor for victory is steadfastness of purpose, a clear vision of the goal, and a determination to win. This is particularly true if the enemy for the time being is apparently victorious and defeat stares us in the face. Then if ever is the time to tighten the grip and determine to fight to the finish.

Let us have no delusions about the war—our war. Germany is winning it to-day, has been winning it for some time past; not always by force of arms, but often by the poison of subtle propaganda. We have only begun to play our part, and the peak of our participation cannot come for another year or more. In the meantime many demands are going to be made on us, one of which is to translate patriotism into dollars and make a success of our Liberty Loans. There must be no wavering, no question of success. If the United States is to come out of this war more than an economic vassal of her enemy; if the chemical and metallurgical industries of this country are to endure; if we are to hold what we have gained and protect what we have already given, then there is naught for us to do but respond to every call. We haven't yet begun to sacrifice in this country; we have yet to earn that glory.

Our supplement to this issue typifies the spirit of unity we would engender in our people—a spirit that will say with Lincoln, "We accepted this war for a just and worthy object and the war will end when that object is attained. Under God, I hope it will not end until that time."

The Need for Chemical Statistics

FOR some time past the conviction has been growing that a beginning should be made toward the gathering and publication of vital statistics in the chemical industry. As nearly as we can ascertain, there is a feeling that our chemical industry has become established on a fairly firm foundation; that the war has lasted long enough to insure a degree of permanence that would have been impossible if Germany had achieved her ends by a swift stroke; and finally that the longer the war lasts the more certain will be our chemical independence. If these things are true—and we believe they are—we should have better facilities for exact knowledge of the industry. Specifically we should have organized sources of information as to imports, exports, raw materials, finished products, production and consumption. These data are a necessary guide to logical and sound development in the industry.

We believe that the work should be undertaken by the cooperation of established government agencies. Since many of the raw materials of chemical manufac-

ture are of a mineral nature, and inasmuch as the United States Geological Survey has already extended the scope of "Mineral Resources of the United States" to include potash, sulphuric acid, cement, phosphate, etc., we suggest that a beginning be made here and that the work be elaborated. It would be of incalculable value at this stage of our growth to have chemical statistics and data comparable to those which the mineral industry enjoys. If the Survey is not the agency for this work, the Bureau of Mines may be.

Happily a beginning has been made toward a knowledge of our chemical imports. Dr. E. R. Pickerell, chemist in charge of the United States Appraiser's Laboratory, New York, is gathering data for the year prior to the war, June 1, 1913 to June 30, 1914. The completed work will show what competition we will have to meet and what essentials we will have to produce. This should be continued as an annual report and extended to cover exports as well. Such data combined with the domestic statistics previously suggested will fortify the chemical industry immeasurably. In established government agencies like the Bureau of Foreign and Domestic Commerce, the Geological Survey and the Bureau of Mines we have the machinery to make a quick start toward exact knowledge of the chemical industry.

Electric Furnaces for Zinc Melting

WE HAVE always held and often expressed a faith in the rôle of the electric furnace in the metallurgy of zinc. Proponents of the retort furnace are still prone to lift their eyebrows skeptically whenever electric-furnace spelter is mentioned; but the most partisan of these adherents must have seen a great light in the sudden perfecting of as difficult and elusive a process—zinc from electrolytic tanks. The economic reduction of zinc oxide by electrothermal methods is as well established as the reduction of zinc sulphate by electrochemical, and he would be stubbornly foolish to maintain that the remaining problem of economic condensation is unsolvable.

However, the electric furnace will undoubtedly come into its own as a melter of zinc metal and alloys before its common adoption for reduction purposes. Electric brass-melting is in its infancy, but even so the installation of the first furnace has been generally followed by additional units. Naturally some failures have resulted in trying to adapt the furnace to its duty: as an extreme instance, an arc furnace for melting zinc would be as useful as a bull jig for slime concentration. Brief consideration of the problem of melting a fusible, volatile and combustible metal seems to indicate the need of a moderate furnace temperature, preferably with heat applied below the bath and a closed laboratory containing an atmosphere controlled as to composition and pressure. These ideals involve structural complications which may be impossible to attain fully in large-capacity furnaces, even though it may now be possible to build and operate small induction furnaces under such conditions. Large furnaces reverberating heat down into the bath from resistors placed alongside fulfill most of the requirements, however, and are operating quite satisfactorily to-day.

The days of the older pot-practice of forming alloys in melting holes seem to be numbered by the growth of foundries producing large tonnages of uniform metal. How long would an electrolytic copper or zinc refinery, for instance, tolerate the melting of a hundred tons of cathodes daily in pot-charges of 200 pounds? The rising cost and decreasing quality of the crucibles, the excessively low thermal efficiency of the fuel used, the huge furnace building and quantities of skilled labor required, alike exclude this practice from a modern metallurgical plant. This whole question has been fought over in the similar problem of the manufacture of tool steel—crucible steel. In both instances the sole justification of crucible practice has been "quality," and the electric furnace has beaten the crucible at its own game!

Tariff Philosophy

NOBODY who is informed can claim that we have ever had a wise, just and equitable tariff bill framed, as a whole, into law. We lacked the tools, the necessary instruments, to make it. We had only congressional committees composed mainly of lawyers; and lawyers, while of necessity a part of the order of life in civilization, are not the creators of civilization. Lawyers are finishers rather than producers.

Now we have an able Tariff Commission to collect and arrange information, but not to legislate, and the play of psychology in legislation is something we must consider. In other words, we must consider beforehand how Congress will feel when it has a tariff act to vote upon. Under our present laws, in regard to certain industries, there are loopholes through which foreign manufacturers can creep with their products and disorganize American industry by sheer astuteness, without even employing deceit. They can do this within the law. An easy way to avoid this danger is to stop up the loopholes by raising the tariff imposts. The real way is to go over the laws in good faith and with honest and frank examination of their provisions in detail.

The trouble with the mere process of just boosting the duties is that it raises the cost of things, and when the cost of things goes up public opinion comes down upon it. When public opinion is unfavorable to an increase in tariff rates Congress will not increase them. It makes no difference what the facts are, or where wisdom lies; Congress reflects public opinion, and public opinion is a contagious emotion. Now, emotion is not thoughtful.

It stands to reason, then, that if associations of manufacturers confine themselves to "helping" the Tariff Commission by pointing out only where higher duties are needed, the voice of public opinion, speaking of these persistent efforts, will be to the effect that manufacturers are the same yesterday, to-day, and forever, and that, like cherubim and seraphim, they continually do cry the song that was indicated by the chorus of manufacturers in the Chemical Grand Opera:

"Protection, Protection, we surely need some more;
We need it now and all the time; we've needed it before.
We chant our old Protection Hymn—it shows the easy way
To bring about Prosperity and let us Make some Hay."

And when public opinion concludes that manufacturers are presenting their claims with minds single to their own interests, and without consideration of the public welfare, like a lawyer trying a case at court who leaves all unfavorable evidence to be developed by opposing counsel, public opinion will close its mind to their appeal, and manufacturers will have no standing at its court, which is the Congress.

The Tariff Committees of Manufacturers' Associations are likely to fail in their efforts if they conceive their duties in the restricted sense of a lawyer at court. They must conceive their duties rather in the manner of a judge advocate at a court martial, looking for the truth and the general welfare rather than to how much they can get. They should not only give the impression of being fair, but be fair. If they appear before the Tariff Commission they should go with all the evidence instead of only that which favors them, and for every advance they ask they should offer a reduction if possible. Every product that can be made here with reasonable profit in world competition, without duty and without reduction in wages, should be made duty-free. It is the business of the Tariff Commission to discover these things and tell them to Congress; so why should not manufacturers tell them to the commission and aid in the reduction of unnecessary duties so that the tariff wall does not grow up too high? This it has often done in the past, only to fall down again like the walls of Jericho at the blast of public opinion, to the confusion and misery of all.

Public opinion in this country is neither docile nor obedient, as it is in Germany. It is subject also to the sinister influence of yellow newspapers which live by loud noise, and the loudest noise can be made in protest. Constructive thought is not noisy, and therefore it is unavailable to the yellow press. On the other hand, public opinion has a mind to fairness, and if manufacturers show themselves fair and in favor of a fair tariff they will stand a better chance than ever before of getting a fair deal. No one should ask for pork, which in politics means something for nothing, or wage without service. The ear of the public mind is sensitive to the cry for pork, and the response is usually violent—violent and destructive.

A Poor Pig-Iron Showing

THE only favorable reflection that can be made upon the record of pig-iron production in 1917 is that at the end of the year the Government took over the railroads with the intention of getting better service out of them, chiefly by doing things which the Government had not permitted the railroads themselves to do. The year's pig-iron production, as now officially reported, was 38,647,397 gross tons, against 39,434,797 tons in 1916, the record year. The decrease of 2.0 per cent is to be considered in connection with the fact that new blast-furnaces, averaging at least 150,000 tons' annual capacity per stack, were blown in as follows: In 1916, one each in May, June, November and December; in 1917, one in the first quarter, five in the second quarter, eight in the third quarter. The eighteen stacks have a capacity of about 3,000,000 tons a year, and considering the times at which they were blown in it is evident they contributed scarcely anything to the 1916 output, whereas the old furnaces and new furnaces combined should have been able to make between 41,000,000 and 41,500,000 tons in 1917.

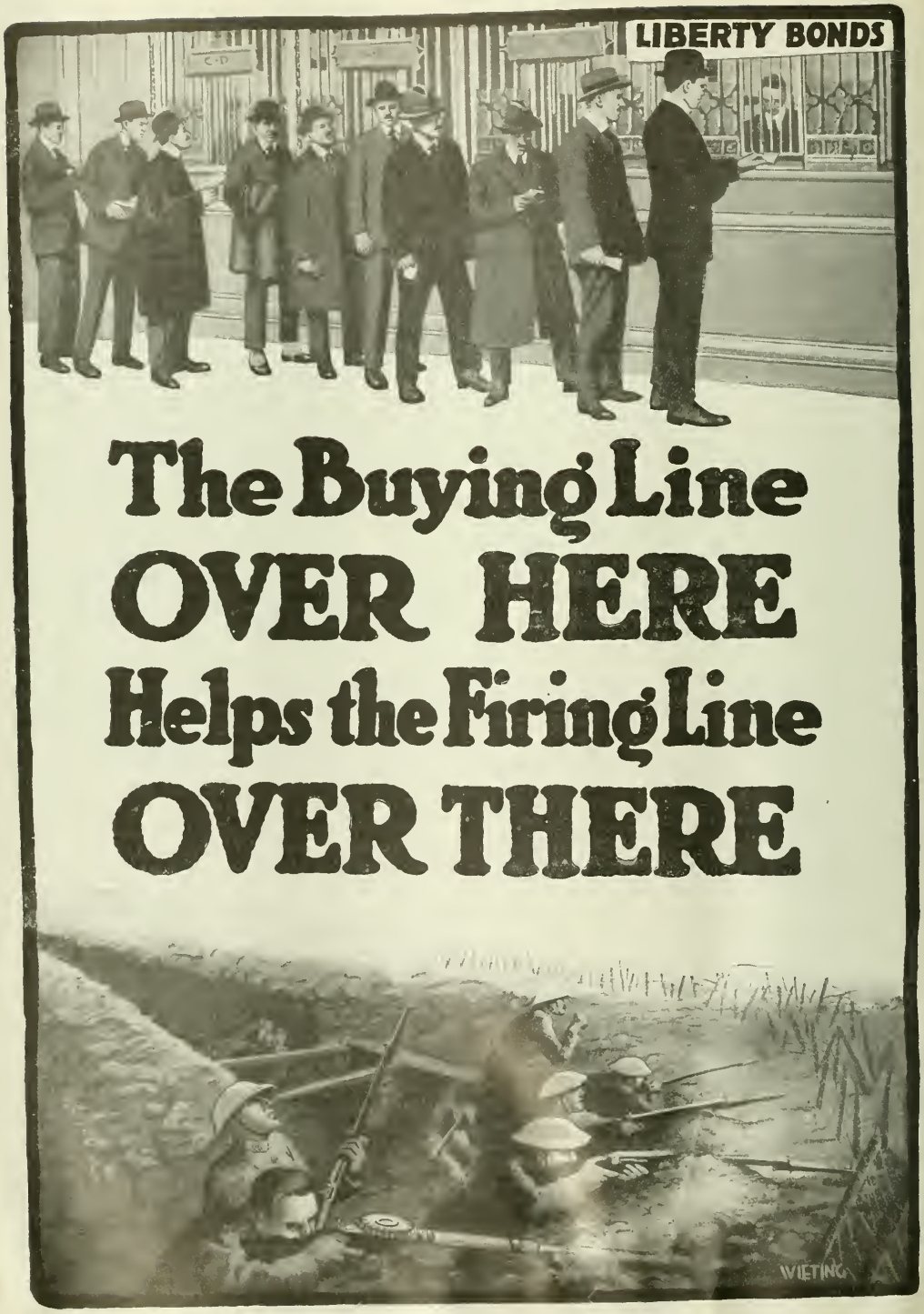
The deficiency of nearly 3,000,000 tons in the 1917 production was due entirely to an insufficient supply of coke. That arose almost wholly from the railroads being unable to haul coal to by-product coke ovens and coke from beehive ovens to furnaces. The shortage in the movement of Connelsville coke, as a matter of fact, began late in November, 1916, and at no time thereafter was there a full movement. The statistics of Connellsville coke shipments, compiled by the *Courier*, show 21,654,502 net tons moved in 1916 and 17,806,-181 tons moved in 1917, a decrease of 3,850,000 net tons, which at 2300 pounds of coke per ton of pig-iron would account for 3,300,000 tons of pig-iron. As a matter of fact, the decrease in pig-iron produced from Connellsville coke was greater than that, because with irregular operation of ovens the quality of coke deteriorated, and with irregular operation of furnaces, including frequent bankings, the coke requirements per ton of pig iron increased. Partial relief was afforded by the output of by-product coke increasing about 3,500,000 tons. The coke troubles did not end with 1917, for conditions were still worse in January and February of this year, and it is doubtful whether even now the rate of pig-iron production is up to the average of 1917. For the future it is a case of having hopes.

There were interesting changes in the distribution as to grades of the pig-iron produced in 1916 and 1917. Basic iron, which constituted about 45 per cent of the total make, decreased in output less than 0.1 per cent, while Bessemer decreased 4.9 per cent. The two grades of steel-making iron together decreased 2.3 per cent. Foundry and ferrosilicon decreased 4.1 per cent, while malleable increased no less than 10.2 per cent, although in 1917 it comprised only 2.3 per cent of the total pig-iron output. Ferromanganese output increased from 221,532 tons to 286,000 tons, or 29 per cent. Adding imports, the apparent supply was 312,-460 tons in 1916 and 331,381 tons in 1917.

Although the production of Bessemer and basic pig iron decreased 2.3 per cent from 1916 to 1917 there appears to have been an increase in steel-ingot production, as partial returns indicate an ingot production of 42,-200,000 tons in 1917, against 41,400,000 tons in 1916. There was hardly an increase in old material available, but more likely a decrease. Stocks of works-scrap were probably cleaned up in 1917 in the effort to make as much steel as possible, while whatever stocks of pig iron existed at the beginning of the year were consumed, probably to the extent of more than a million tons.

The total output of basic iron in 1917 was 17,671,662 tons, and of this 15,056,787 tons was produced by consumers. The amount of iron delivered molten for consumption was 13,696,600 tons, and one may safely assume that practically all of this was produced by the producer-consumer class, so that of the basic iron they produced they used direct 90.97 per cent. The proportion of direct metal charged by the same works was much less, on account of the use of stocks.

While the total production of pig iron decreased 2.0 per cent in 1917, the production of merchant iron increased from 11,253,317 tons to 11,676,513 tons, or by 3.8 per cent, the merchant output in 1917 constituting 30 per cent of the total.


LIBERTY BONDS
The Buying Line
OVER HERE
Helps the Firing Line
OVER THERE
WIETING

Our April Business

Patriotic Messages from Representatives of the Chemical and Metallurgical Industries

By William H. Nichols

President American Chemical Society, Chairman of the Board, General Chemical Co.

Like the two loans which preceded it, the Third Liberty Loan affords an opportunity for the American people to show the depth of their patriotism by acts rather than words. This, of course, is true of the chemical industry, as it is of all others, and the opportunity thus afforded to co-operate with our Government should be looked upon as a privilege. This applies as much to the humblest workman as it does to those holding the highest position and, judging from the previous campaigns that have come under my observation, they thoroughly appreciate this. In several of the works of this company every single employee subscribed to the second loan, and in all of the works a very large proportion took bonds. I expect that similar results will be reached in the third loan.

The chemical industry has not been found lacking in any respect since our entry into the war and has consistently done its duty. It realizes that much depends upon it, and will make every effort to do its part until the successful termination.

New York City.

* * *

By Paul J. Kruesi.

President Southern Ferro Alloys Co.

The next big victory of the European war must be won here in the United States. Our success in this loan will be magically reflected in the valorous deeds of our brothers and sons in breaking the deadlock on the western front.

Our April business, therefore, is to make an overwhelming success of the Third War Loan—happily named by Mr. McAdoo the Liberty Loan. Of it we must buy and buy, not what each can comfortably digest, but all that our credit will permit when strained as credit was never strained before. Then when we would preen ourselves on our virtuous patriotism we must take a hand in the selling, making the other fellow do what we have first done ourselves.

Never should we forget or allow him to forget how trivial is the curtailment of our ordinary luxuries and comforts as compared with the privations of war imposed on our gallant allies and our own sons at the front.

In no field should more be expected than in those of electrochemistry and metallurgy, than which none has been more stimulated by war and than which none has more at stake in defeating German world-dominion.

Nations like men are accepted at their own estimates until they fail in their own pretensions. From now on France and England expect the morale of their armies to be sustained by ours. Can anyone picture the demoralization and humiliation were we to fail in a bond issue? The end is measurably near whenever we fail, for our armies and our allies will only be beaten when we are.

Away then with so much talk of peace, for the only kind of peace now would be of the "Made in Germany" brand. Away with the faint-hearted who will argue that the "saturation point" in bond sales has been reached! Away to the internment camps with those worst of slackers who claim they are "too busy" to help sell bonds for the liberty they enjoy!

We, who have been the four-year beneficiaries of all their expenditure of blood and treasure, shall we then falter when our brave allies call "Come, and come with all your speed and might"?

Chattanooga, Tenn.

* * *

By G. W. Thompson

President American Institute of Chemical Engineers

I am indeed glad to join in urging those in the chemical industries to do everything in their power to make this, the Third Liberty Loan, a great success. We must subscribe ourselves—we must urge others to subscribe. If we value the really good things in life, if we have affection for our friends and treasure our family ties, if we hold to any principles on which we believe civilization and progress to rest, this is the time to show it. I believe everyone should step forward and seal his devotion to the cause of liberty now. It is the only way.

Brooklyn, N. Y.

* * *

By J. V. N. Dorr,

President The Dorr Co.

The technical man whose work helps the production of essentials feels himself a slacker when he thinks of those going over to pay with their lives for his freedom. His only salvation is to push his work with every ounce of energy and buy Liberty Bonds with every cent he can save.

This is an engineering war and, if there ever was one, it is a "rush job." The chief engineer must not be hampered by lack of funds, and it is up to us not on the firing line to make up for the lack of preparation which we regret by giving every ounce of our energy and every dollar we can save.

America's reply to the Hun offensive must be such an over subscription to this Liberty bond issue that Germany will realize the nation to the last man is behind the war and prepared to win peace only by victory.

It is up to the technical men who realized our danger when the politicians slept to do more than their share in this loan and then start to save for the next.

New York City.

* * *

By Colin G. Fink

President American Electrochemical Society

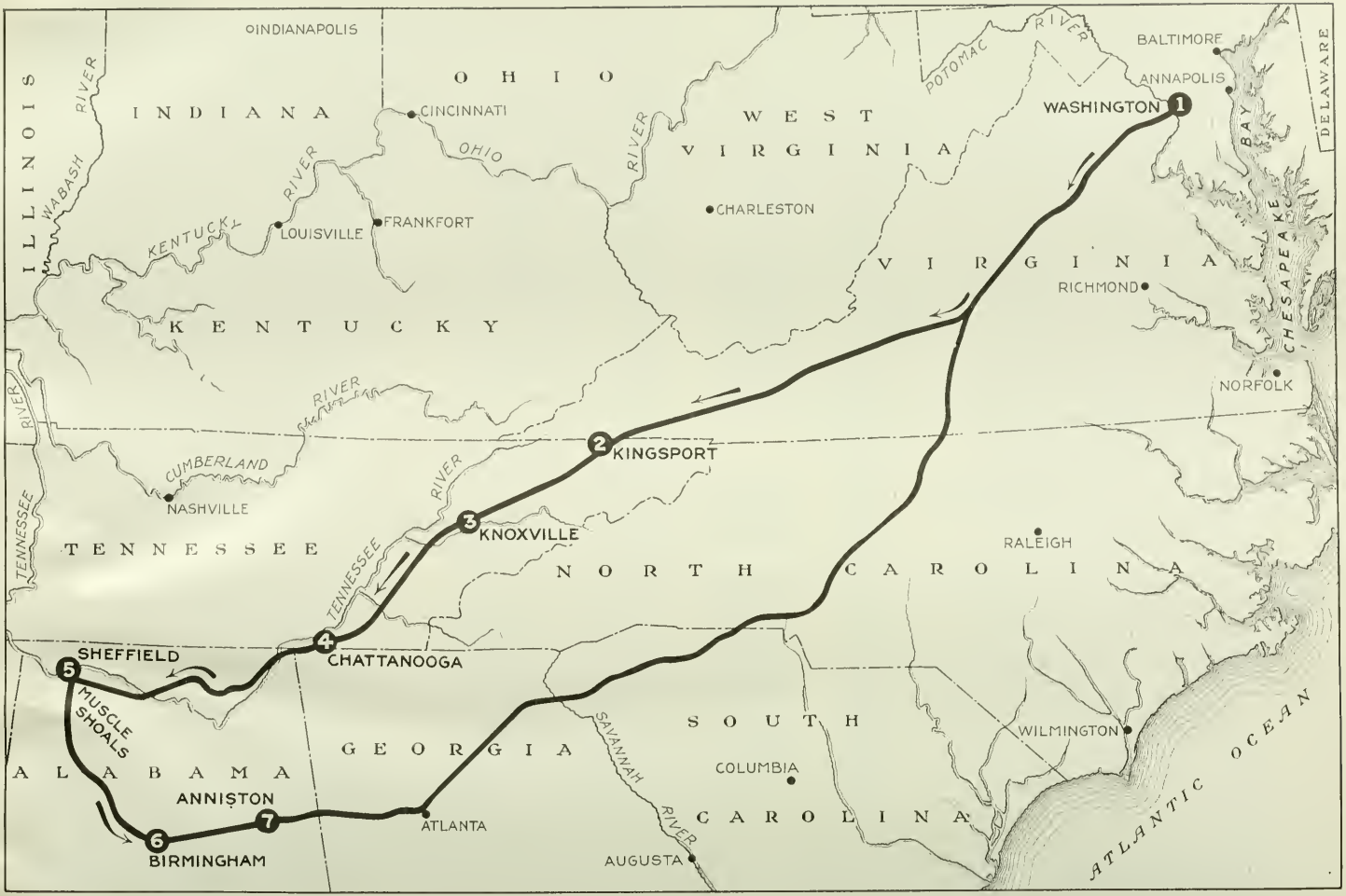
In 1848, when Europe was revolting against monarchies, young Louis Pasteur, while passing through the Place du Panthéon, noticed a little altar with the inscription "Autel de la Patrie." The words kindled his patriotic spirit, and he offered at once his entire humble fortune of 150 francs. The same spirit that pervaded the scientific researches of Pasteur, resulting in so many world successes—this same spirit in its patriotic guise led him to enroll in the National Guards and offer his meager savings besides.

In our appeal to-day to electrochemists and metallurgists to contribute and assist in making the Third Liberty Loan a most emphatic and unparalleled success, we feel thoroughly confident that we need not impress upon them the dire consequences of a possible failure of this loan campaign. A scientific mind will easily appreciate the results. Lack of financial support means defeat. Unless we loan our money to the Government to-day we will have to forfeit it later to the German invader.

President Hibben of Princeton recently remarked to a large audience of engineers, "Germany is winning this war." Our American newspapers have been pursuing a policy of minimizing German successes, with the result that many of our people do not realize that Germany is winning this war. They look upon the task that we have undertaken rather lightly and feel as though the Government will easily handle the situation without any support from the individual. The fact is that our task is a very difficult one. Win we must, and win we shall, but it will require the utmost effort of every man. We must support the Government in every detail of its complex war program. In order to keep our soldiers and sailors well supplied with the very best in munitions and provisions our Government requires money, much money, and more money! Hundreds of ships must be built, thousands of shells and guns manufactured and millions of tons of wheat and meat transported across the Atlantic.

Put your shoulder to the wheel. If you cannot go to France and fight, do all you can to help those that are fighting for you. If you are not yet convinced that you must support the Government financially, don't stop until you are convinced. And if you are convinced, don't stop until you have convinced others. On April 4 it will be just one hundred years since the adoption of our flag by Congress. Let us make this anniversary one worthy of the high ideals our flag represents!

New York City.



ROUTE OF SOUTHERN TRIP, AMERICAN ELECTROCHEMICAL SOCIETY, APRIL 28-MAY 5.

Spring Meeting and Southern Trip of American Electrochemical Society

Tentative Program of Visit to Technical Centers of Tennessee and Alabama, Including Government Projects at Muscle Shoals

WITH the official approval of the Director General of Railroads, the final plans of the American Electrochemical Society for its spring meeting and Southern trip are rapidly nearing completion. For the benefit and information of those who have decided or may yet decide to join the party, we give a provisional program and outline of the trip.

Itinerary

1. Washington, D. C., Sunday, April 28. The party will gather at this point and leave some time late in the afternoon over the route shown in the sketch map on the opposite page. Stops will be made at six points, spending one day or part of a day at each place. The general plan contemplates visits to industrial plants and hydroelectric power stations during the day, with technical sessions in the evenings. Returning, the party will reach Washington some time Sunday morning, May 5.

2. Kingsport, Tenn., Monday, April 29. This community enjoys the distinction of having a complete cycle of chemical and electrochemical industries, interrelated and co-ordinated to an unusual degree.

It is planned to arrive in time for breakfast and spend the day visiting plants, stopping at noon for lunch at Rotherwood Farm. Following are the industries and points of interest: Federal Dyestuff & Chemical Company, electrolytic chlorine plant, Allen cells; Kingsport Brick Corporation; Clinchfield Portland Cement Corporation, Cottrell plant for potash recovery, and steam-electric power plant; Kingsport Extract Corporation, oak and chestnut tanning extracts used by the Kingsport Tanning Corporation; Kingsport Pulp Corporation, paper pulp from spent chips from extract mill; Kingsport Paper Corporation; two alcohol plants.

In the evening there will be a dinner at the Inn, followed by the annual business meeting, motion pictures, dancing, etc. A special exhibit of minerals of the region will be on display.

3. Knoxville District, Tenn., Tuesday, April 30. A preliminary stop will be made at Mascot for breakfast and a visit to the zinc concentrating mill of the American Zinc, Lead & Smelting Company. The oil flotation process is in use here. Arriving at Knoxville, there may be a technical session until lunch time, after which the party will be taken to one of the dam sites of the Aluminum Company of America on the Little Tennessee River. This development is planned to yield 400,000 hp. and is typical of such power possibilities in the region. In the evening there will be a banquet at the Country Club and a lecture by Prof. Switzer of the University of Tennessee on the hydroelectric and industrial resources of the region. This lecture has been specially prepared in anticipation of the meeting.

4. Chattanooga, Tenn., Wednesday, May 1. At this point are the plants of the Kalbfleisch Chemical Company, sulphuric acid and alum; the Chattanooga Gas & Coal Products Company, the Southern Ferro Alloys Company, ferrosilicon, and Wilson & Company, cotton seed oil. There are also a modern bleachery, textile mill and government munition plant. An afternoon boat trip is planned to Hale Bar, where the Tennessee Power Company has a dam and power plant developing 100,000 hp. A complimentary banquet will be served in the evening.

5. Sheffield and Muscle Shoals, Ala., Thursday, May 2. This region is famous for its power possibilities and for the location of two plants for fixation of atmospheric nitrogen. The government is building and will operate a nitrate plant for the synthesis and oxidation of ammonia. The Air Nitrates Corporation is the agent of the Ordnance Department, U. S. A., for the manufacture of ammonium nitrate by the cyanamide process. Construction is well advanced on the nitrate plant and may be under way on the cyanamide plant. In addition to inspecting these plants as far as possible, the party will go by boat up through Muscle Shoals of the Tennessee River. President Wilson recently signed an order for the development of one of the power sites on the shoals to provide 600,000 hp.

6. Birmingham, Ala., Friday, May 3. This district is known for its iron and steel manufacture, to which has been added ferromanganese. The Tennessee Coal, Iron & Railroad Company at Bessemer makes ferromanganese in a blast furnace, and steel by the duplex process. At Ensley there is a by-product coke plant. Plans for this stop are yet to be completed.

7. Anniston, Ala., Saturday, May 4. A short stop of perhaps four hours is planned. At this point are the electric furnace plants of the Anniston Steel Company, making low-phosphorus pig iron and electric steel castings, and the Southern Manganese Corporation, making ferro-manganese and either ferro-chrome or silicon.

The following estimate of expense has been submitted by the railroads, based on carrying 100 persons. Figures include war tax. Transportation, $41.96; upper berth, $15; lower, $19; stateroom or compartment for two, $22 each; drawing room for three, $25 each. Leaving Anniston on the return trip, meals will be served on diner at table d'hote rate of $1.25 per meal. Railroad equipment will comprise one baggage car and pullmans, and it is anticipated that one of the latter will be a combination compartment and observation car.

In making visits to plants it is understood that competitors will not accept the courtesy unless they reciprocate it.

Those expecting to take the trip should notify J. W. Richards, secretary, Lehigh University, South Bethlehem, Pa., making their reservations and sending remittances to him. Any who expect to take only part of the trip should communicate with C. A. Kline, Southern Railway, Washington, D. C.

Readers' Views and Comments

Engineers in Training

To the Editor of Metallurgical & Chemical Engineering

SIR:—I have read with interest Professor Hill's article in the issue of your journal for December 15. It is of especial interest because some three years ago we established a new course at the Massachusetts Institute of Technology, entitled Engineering Administration, and in June of last year we graduated our first class in this course, numbering thirty-seven men. We could have placed a far larger number than those who graduated. Military service has called two-thirds of them at once, and it is rapidly extending its claims to the remainder, but such experience as we have had shows that there is a very specific demand for men who are engineers and who had their attention called to the problems of business management and human relationships which enter into industrial affairs.

DAVIS R. DEWEY.

Cambridge, Mass.

* * *

To the Editor of Metallurgical & Chemical Engineering

SIR: The humanizing and broadening of technical and engineering training are certainly most desirable, but the method of doing this must be most carefully guarded and many of the efforts thus far made are, I think, open to criticism. They most certainly have not attained the desired result and instead of cultivating a desire on the part of engineering students for economic and literary studies have had rather the opposite effect. If, as is sometimes the case, the courses in economics, sociology, etc., are recognized as the "snap" courses, which, though required of engineering students, are taken simply to ease up the program, I question if any satisfactory results will be obtained.

I happen to know of one instance where a young man through sickness was able to attend classes in one such subject for only a month out of the entire semester, yet he was permitted to take the examination without tutoring or doing any work excepting, as he himself put it, cramming for one day before the examination, and passed it. Certainly if this can be done a student is wasting his time by attending lectures throughout an entire semester.

The gist of the subject seems to me is contained in Prof. Hill's conclusion 8, "Non-technical instruction for technical students must be as efficient as technical instruction. Teachers through their own training and experience must be able to relate the non-technical teaching to definitely discover conditions and needs of the technical world itself."

I seriously question the advisability of having engineering students take, for instance, a course in labor problems given by a recent graduate in economics, who has yet to make the real acquaintance of a laboring man, but if such a course can be given by some one, be he an engineer or economist, who has actually been up against the labor problem, such a course would be most valuable.

One solution of the problem is the humanizing of technical subjects by emphasizing the economic, political, and sociological phases, for which there is ample opportunity in most technical courses. For instance, economic geology lends itself admirably to the discussion of many current economic problems cognate to, but not ordinarily included under the head of geology. Such a strictly engineering course as the utilization of fuels certainly offers scope for a discussion of such pertinent economic problems as the recent coal situation. While I think that practically all teachers of engineering agree in the opinion that a liberalizing of our courses is advisable, the best way in which to solve the difficulty is by no means a settled question and many of the experiments now being made are not only not producing the results aimed at, but are taking the time which might better be spent on more distinctly technical subjects.

H. H. STOEK.

Urbana, Ill.

* * *

To the Editor of Metallurgical & Chemical Engineering

Sir:—During recent years a good many people have urged the importance of including courses in business administration, economics, accountancy and other similar subjects in the engineering curriculums with a view to familiarizing undergraduate students with some of the business practices of the commercial world. I have much sympathy with the desire that we turn out graduates from the technical schools who are well prepared to engage in commercial work, and I assume that sooner or later the engineering colleges will give way to the pressure which is likely to be brought to bear upon them for a modification of their curriculums so that they will include an increasing number of non-technical subjects. Five or six years ago the College of Engineering of the University of Illinois completely revised its various curriculums with a view to including a certain number of non-technical electives, in the expectation that students would be given a greater breadth of knowledge and that they might better compete with men of so-called liberal training. If I were to ask the members of our faculty their views of the success of our efforts to "liberalize" our curriculums I am inclined to think that the general opinion would be that the plan has not worked out as we had hoped, largely, perhaps, because the students themselves have too little appreciation of the probable demands of the future to select their electives wisely.

The engineering colleges of the country have been organized to give instruction in the fundamentals of engineering, with some specialization in various technical subjects. On the whole, I think that they have done a pretty good job in the training of men for technical engineering positions. We will all agree, I believe, that the graduates of the engineering schools are not engineers and that the best we can do is to give them the foundation for an engineering career. We are continually endeavoring to bring into the curriculums new technical courses to prepare men in various specialties which have developed as a result of the constant progress that is being made in

engineering science. In addition, as has been indicated, pressure is being brought to bear to include the so-called business courses in the engineering curriculums. Personally, I doubt whether it is possible to make many changes of this sort in a four-year curriculum without some danger that the basic subjects may be given reduced importance. If such changes should be made we may ultimately turn out men who are inadequately prepared either for engineering or for business. Perhaps the final solution of the problem will lie in the extension of the time required for the completion of an engineering course to five or even to six years.

In spite of my doubts regarding the propriety of including much instruction in the principles of business in the four-year engineering curriculum I recognize that the engineer of the future must play a larger part in the social and economic life of the community. During the reconstruction period which will follow the war, the principal problems to be met will be those of a social and economic nature. In one way or another the engineer must play a part in this reconstruction work, and it will undoubtedly be to the advantage of the country if his understanding of these problems is such that his influence may be employed to secure the largest measure of public good.

C. R. RICHARDS.

Urbana, Ill.

Poison Gases in the War

AT the regular March meeting of the Chicago Section of the American Chemical Society, held at the City Club on Friday evening, March 15, 1918, Major S. J. M. AULD, chemical adviser of the British Military Mission, thrilled his audience for about two hours with a description of the part played by gas in modern warfare. He described the first gas attack made by the Germans early in the war and the gallant resistance of the heroic men who met it without even the most primitive means of defense. He proceeded to tell about the development of the gas offensive from the first gas-cloud attack with chlorine to the use of phosgene, various tear and sneeze-producing gases, poison gases, and finally the latest accomplishments with gas shells. The great magnitude with which some of these attacks were carried on may be impressed upon us by learning that hundreds of tons of liquid chlorine have been used in a single attack, and that in some cases the drums of chlorine were placed so closely together that there were three for each two yards along a front of considerable length. The effect of weather conditions, the direction and velocity of the wind, the factor of safety, and many other details were explained.

In recent attacks with gas shells, as many as 35,000 to 50,000 shells have been dropped on a limited acreage in two or three hours. Some of the gas shells contained, in addition to the bursting charge of high explosive, bottles containing liquid, and in some cases even solid chemicals, which would be so completely atomized by the bursting of the shell that they would have the same effects as shells charged with liquefied gases. It was stated that a case was on record in which a shell which failed to explode was examined and found to contain bottles with the original Kahlbaum labels still intact.

Passing to the defensive, the speaker described the development of the gas mask from a simple cloth bandage soaked in various chemicals to the elaborate mask which is now in universal use. As fast as the enemy introduced new devices for gas offense a suitable defense was provided to overcome it. The experience was bitter and costly, but at the present time the idea is prevalent that the worst is over, and that the defense is, in general, developed to a greater degree of efficiency than the offense.

It was very gratifying to hear him say that the mask produced by the Americans, and now in general use at the front, was considered superior to any of the others. Not only are the men provided with masks, but even the horses, mules and carrier pigeons are provided for. In the case of the horses and mules, as these animals breathe through the nose, a mask made of cloth soaked in chemicals is drawn over the nostrils. In the case of the pigeons, however, each bird is not provided with a separate mask. The cages in which they are confined are covered with preparations which prevent any of the objectionable gases reaching the interior.

In the composition of gas masks designed to neutralize the effects of chlorine and phosgene, the chemicals most used are sodium thiosulphate, sodium phenate, activated charcoal, and hexamethylene-tetramine.

Montreal Meeting of Canadian Mining Institute

THE twentieth annual meeting of the Canadian Mining Institute was held at the Windsor Hotel in Montreal, March 6 to 8. The meeting was opened on Wednesday morning, March 6, by Arthur A. Cole, president of the Institute. About 125 to 150 members were present, including several from the United States.

The report of the Council and the financial statement for 1917 were read and adopted.

The presidential address was then delivered by Mr. Cole. He showed how Canada had passed from a borrowing to a self-supporting nation since the war started. He said that one-ninth of the wage earners in Canada in 1915 were employed in the mining and dependent industries and 37.9 per cent of the tonnage supplied to the railways was the product of mines. He mentioned the large number of electric furnaces used in war work for the production of shell steel from turnings, and also the new industries of copper and zinc refining and magnesium production. He thought it highly desirable to keep the gold mines producing in order to maintain a gold reserve. He said one of the main deficiencies in natural resources was the lack of fuel in Central Canada. This could be partly relieved by a greater use of water power. In regard to a proposition put forth that all engineers should combine in a single society, he did not think this advisable owing to the different branches being so specialized, and during times of stress cooperation is easily secured between the executives of the different engineering societies.

A proposal by Dr. A. Stansfield to change the name of the society to the Canadian Mining and Metallurgical Institute was postponed for a year pending the formation of an iron and steel section.

Mr. D. B. Dowling of Ottawa was elected president and Messrs. J. A. Dresser, H. E. T. Haultain and A. E. Whiteside were elected vice presidents.

Councillors were elected by acclamation as follows:

Quebec—Alfred Stansfield, Montreal.

Ontario—N. R. Fisher, Haileybury, Ont.
R. E. Hore, Toronto, Ont.
E. P. Mathewson, Toronto, Ont.
S. B. Wright, Deloro.

Alberta—Jules Charbonnier, Blairmore.
W. P. Williams, Bellevieu.

British Columbia—R. H. Stewart, Vancouver.
George Wilkinson, Victoria.
W. R. Wilson, Fernie.

At the luncheon on Wednesday President Cole announced that a resolution had been unanimously passed by the Council to commemorate the twentieth annual meeting of the Institute by conferring life membership on their first president, Mr. John E. Hardman of Montreal, and Mr. J. Stevenson Brown of Montreal, who was for many years their treasurer.

The report of the Council showed that there had been a large increase in membership during the year. There were 125 members on active service, and eleven members had been killed in action. The total membership was 1118, as against 1066 in 1916.

A smoker was held on Thursday evening, at which the principal event was a paper on the Quebec Bridge, illustrated by lantern slides by Col. C. N. Monsarrat. He described the construction of the bridge completely from the work on the material in the shops to the final opening of the bridge for regular traffic.

The annual dinner was held Friday evening, at which Hon. Martin Burrell was the chief speaker. Mr. Burrell is the Minister of Mines in the new Federal Government.

A long list of papers was read in the three days, including general subjects, coal and fuel, flotation, iron and steel, ferro-alloys, mining, geology, etc.

Among those present at the meetings from the United States were Bradley Stoughton, secretary American Institute of Mining Engineers, New York; Eli T. Conner, Scranton, Pa.; C. Seymour Newcomb, New York, and H. M. Roberts, Minneapolis, Minn.

Toluol from Sulphite Wood-Pulp

IN our last issue we published a note on the possibility of augmenting our supply of toluol by treating the so-called spruce turpentine obtained from sulphite wood-pulp. This material is more properly known as sulphite turpentine or cymene. Its recovery has been made the subject of study by a special committee on toluol of the Technical Association of the Paper & Pulp Industry, and an official report has just been made by Henry E. Fletcher, chairman of the committee, to Captain H. C. Porter of the Ordnance Department recommending the adoption of a method developed by the Hammermill Paper Company. The report, which has reference to the accompanying diagram of the process, is as follows:

The committee has taken up this question by correspondence with various mill operators and chemists, and has come to the conclusion that the best system in vogue at present is the one that has been adopted by the Hammermill Paper Company of Erie, Pa., which has very generously offered the use of this method to any mill. The method is as follows:

Separating the relief gases and liquor, sending the relief gases through the gas cooler to a second separator *B*, shown on the accompanying sketch, this separator taking out the cymene plus a certain quantity of other condensates. You will note the dimensions of this separator for both the intake and discharge are about 6 in. in diameter and the separator itself about 15 in. in diameter and 5 ft. deep. There is a lead baffle-plate placed in the middle of the separator reaching to within a foot of the bottom. In the bottom of the separator is an outlet of about 2 in. diameter, which conducts to a separating tank the cymene, together with an aqueous SO_2 solution. This tank should be equipped with gage glass and indicator cocks. It may be noted here that the gage glass shown is subject to freezing and it would be more advisable to have a stave mortised and a section of from ¼ to ½ inch plate glass inserted from 2 to 3 in. wide and 4 ft. long, answering as a window to the tank itself. From here we draw the aqueous solution of SO_2 from the bottom of the tank back to the acid storage tanks, and the cymene to tanks for the purpose of collecting the same. The more frequently this operation is repeated the better the resulting production will be.

The adoption of the method and the largest possible production of toluol, regardless of cost or profit, is urged on all pulp makers as a patriotic duty.

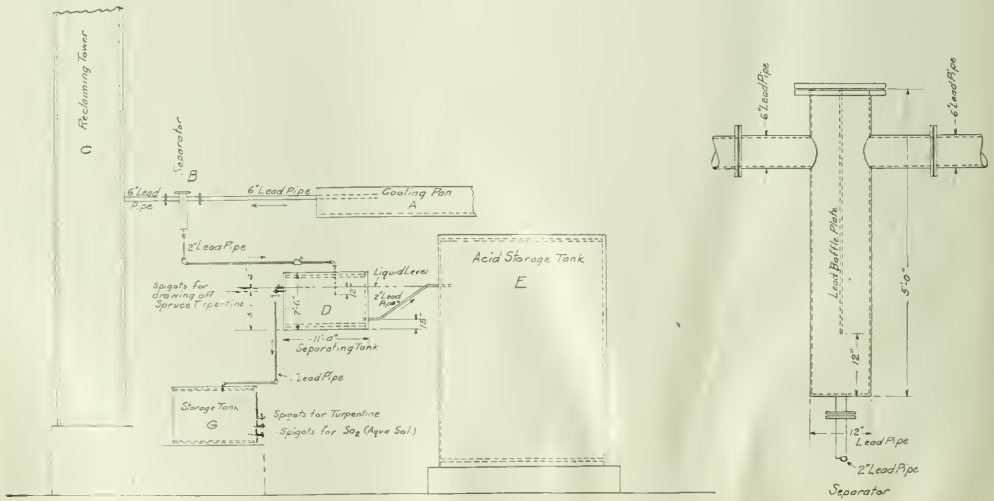


DIAGRAM OF METHOD FOR RECOVERY OF SULPHITE TURPENTINE, OR CYMENE, FOR TOLUOL MANUFACTURE

Hearings on Federal Water-Power Bill

Congressional Committee Is Enlightened on Provisions of New Measure Proposed by the Administration—Prospect Favorable for Enactment

WATER-POWER development under the terms of the so-called Administration bill was the subject of hearings last week before a special power committee of the House of Representatives. To those who have attended hearings in the past when similar measures were under consideration it was apparent that the prospect for successful legislation is now more favorable than at any previous time. There was a notable absence of the professional lobby, and the speakers who appeared before the committee presented sound and impartial facts. The attitude of the committee itself showed a desire to ascertain the truth in order that fair legislation might be speedily enacted. In short, the entire atmosphere was different to that of previous hearings, and there were evidences of unity of desire and purpose.

The course of the proceedings disclosed the particular features of water-power development in which different members of the committee are specially interested. Chairman Sims of Tennessee expressed regret that the bill did not contemplate securing revenue for the federal government, and repeatedly interrogated witnesses on the advisability of making such provision. He was unsuccessful in eliciting affirmative views. Congressman Taylor of Colorado asked all witnesses whether there existed such a thing as a water-power trust, and succeeded in reading into the record a complete denial of the existence of such a combination in the several states represented by the witnesses. Congressman Esch of Wisconsin reverted to parallel provisions in previous bills and interrogated witnesses on the relative merits of the different measures. In practically all cases the replies showed the superiority of the Administration bill.

Among the witnesses there was practical unanimity of opinion that the present bill is the best that has been proposed, and that with a few minor modifications it would be a workable measure. While it does not and will not contain everything that everybody thinks should be in it, there was expressed a willingness on the part of power men to accept the bill with slight modifications.

The Government's Position

Mr. C. O. Merrill, chief engineer of the Forest Service, Department of Agriculture, stated the government's position on the measure. He spoke for the Secretaries of War, Agriculture and the Interior, who are named in the bill as a federal power commission. He spoke in part as follows:

"The industrial expansion caused by the demand for materials and supplies needed in the prosecution of the war, together with the huge financial requirements of the government, have materially changed the pre-war status of the electric power industry. The demand for power has increased notwithstanding increased costs of construction and operation. Increased operating costs have reduced the ratio of income to revenue, and this reduction combined with the decrease in supply of available investment capital has produced a situation with respect to public utilities, among which is electric power development, that merits the early attention of Congress."

He then reviewed the upward trend of prices for the past five years, showing the following advances: Hydraulic machinery, 100 per cent to 150 per cent; electric apparatus, 125 per cent to 150 per cent; steam turbine generators, 150 per cent; water-tube boilers, 170 per cent. In like manner the scarcity of labor and increase in wages have added to costs of construction. Encroachment on fuel-oil reserves and the scarcity of coal have their effect on power development, particularly on the Pacific Coast. All of these items have resulted in increased cost of steam power and have made hydroelectric development more attractive and more necessary.

More Power Needed

"Notwithstanding increased costs of construction and of operation the demand for power has increased, not at a uniform but at an accelerating rate, until during the past two years the annual increment in power generated by commercial central stations alone has been from three to four billion kilowatt-hours, requiring an annual increase in installation of from one and one-half to two million horsepower.

"The demand for power will continue to increase while war continues, in order to supply power to our constantly expanding war industries; and when the war is over, to provide for the extension of public utilities and of the electrochemical industries, for electrification of railroads, and for the multitude of other activities that will accompany the period of reconstruction."

The difficulties in the way of financing power projects were shown by Mr. Merrill, who contended, however, that development could not stop and that legislation should be enacted which would offer the most favorable terms for new projects. He showed the necessity for increased efficiency in existing developments and the desirability of interconnection of isolated plants. In his opinion no considerable development of Eastern water-power will come about except through interconnection of plants over wide territories, in order that the diversity of demand may raise the load factor of the combined system to a point where steam-power competition can be met. This point was forcibly illustrated by a map of California, with its interconnected systems, superposed on the Atlantic States.

Needs of the Future

The Administration bill gives consideration to the needs of the future, Mr. Merrill said, and anticipates the period of reconstruction after the war, when labor will be scarce and mechanical power in greater demand.

Our electrochemical industries, developing under the stimulus of war demands and the cessation of imports, will require increasing amounts of electric power if the United States is to take its place as a competitor in the world's markets or even supply domestic demands. Intensive studies should be made of power sites or groups of sites with relation to particular power needs. Mr. Merrill concluded:

"The shortage of fuel, the overloading of our transportation systems, the demand for industrial power and the unsatisfactory financial situation of our public utilities emphasize as never before the imperative need of immediate, adequate and comprehensive legislation. Our industrial efficiency, both during the war and thereafter, will be increased or diminished according to whether we do or do not make adequate provision for the development of our water-power resources. In view of these circumstances it is submitted that water-power legislation should be considered a war emergency measure and as such should be taken up by Congress and passed at an early date.

In response to questions by members of the committee, Mr. Merrill gave his opinion on the following points:

The terms of a license should be absolutely definite and unchangeable for the entire period of issue. This is quite necessary in order to prevent any uncertainty in the mind of the licensee as to the conditions under which he can operate.

The idea of the rental charge is not to secure revenue for the government, but it is made in return for the issuance of a license. The money thus received is to be used (1) to defray the cost of administration and (2) the possible necessity of recovering excess earnings which it is impossible to reach in any other way.

While the rentals should be nominal they should be greater in those cases where the government contributed land or some other tangible property to a project, and less where the government has nothing to offer but the license. Whatever provision is made should be clearly stated in the license before it is accepted by the licensee. It was Mr. Merrill's opinion that it would be a better fiscal policy to charge a rental which would be nominal and which would not reduce earnings below a fair return or increase rates to the consumer. As between getting revenue for the government and reducing rates to the consumer, rental charges should operate in favor of the latter.

Rate regulation on interstate business should be left to the several State authorities and handled locally as long as local authorities show the ability to act and as long as there is no disagreement between States. Federal jurisdiction should come in when other authority is insufficient.

The recapture clause is considered to be the most important in the bill, and it was Mr. Merrill's opinion that the basis for recapture should be the actual legitimate original cost of the property plus additions, less any funds accumulated in unappropriated surplus or for the purpose of providing for depreciation of equipment or amortization of investment. The price should allow nothing, however, for any unearned increment in value of the property, good will, going-value, or expected profit.

Improving a Navigable River

Mr. Henry J. Pierce of the Washington Irrigation & Development Company explained to the committee the features of a project for the development of power, improvement of navigation and irrigation of land at Priest Rapids on the Columbia River. This stream is now navigable for steamers of 1000 tons capacity for 400 miles from its mouth at the Pacific Ocean. The construction of a proposed dam and locks would add 200 miles of navigable waters, through a region almost without railroad facilities. The dam would cost $25,000,000, and will permit of the development of 250,000 hp. throughout the year, and an additional 250,000 hp. or more during the high-water period. This period corresponds with the irrigation season, so that by a fortunate coincidence there would be water for irrigation and power for lifting it to the upper lands.

The witness showed a map of the United States and its navigable waterways. Practically all are in the East. On the other hand, 62 per cent of the area of eleven public-domain states in the West is under federal control, where over 60 per cent of the wasting water powers of the country are located. Mr. Pierce dwelt on the hazardous nature of waterpower undertakings and the necessity for removing onerous terms from licenses for development. In his opinion the bill under consideration was fair toward the investor and operator, while protecting public interest. He asked that a holder of a priority permit be protected in all expenditures made in good faith in the development of water power and that he be given the preference to a permit as against others who have not expended time nor money. He also asked that any tax imposed should be on the actual power developed, and that in case the license is to be renewed the original licensee have the first right.

Mr. Calvert Townley, assistant to the president of the Westinghouse Electric & Manufacturing Company, repeated part of a statement made before the United States Chamber of Commerce. It was his opinion that even favorable legislation would not stimulate water-power development because of competition with the steam turbine and the comparatively low cost of construction of a steam-electric plant.

The Investor's Viewpoint

Mr. E. K. Hall, vice-president of the Electric Bond & Share Company discussed the bill in its financial aspects. From the point of view of the investor there are two fundamental defects in the bill. The contract has been made definite and the investor knows what he is getting and what is expected of him. He is assured of the enjoyment of the privilege for fifty years and of the return of his capital at the end of that period if the government at that time wishes to recapture the project. But if the government does not want to take the property he must continue to run it under an indeterminate and uncertain tenure. He cannot issue refunding bonds, because he does not know how long he may be allowed to hold the property. For this reason Mr. Hall urged that if the government did not wish to take or transfer the property on the expiration of the license it should be reissued to the holder for a term of thirty years.

The other defect was the provision for recapture of

the property at the expiration of the license on payment of the net investment. This assured the investor the return of what he had put into the project and had not already taken out besides his fair profit, but did not allow him to profit by the enhanced value of the land. In all other businesses the investor was allowed, besides what fair current profit he could make, to benefit by an increase in the value of the property while in his hands. In response to an inquiry by a member of the committee, Mr. Hall said he considered this the best bill yet offered.

Power Development in California

Mr. John A. Britton, vice-president and general manager of the Pacific Gas & Electric Company, showed the relation of hydroelectric development in California to the upbuilding of the state. He joined other witnesses in saying that the administration waterpower bill was good in its main features, but that some provision should be made to except from the full terms of the bill those projects which were only in part—and sometimes a very small part—constructed on government land. He cited two cases in California in support of his contention. In one case a reservoir project includes 38 acres of "forest reserve," which is really a rocky, barren waste, but which is flooded when the reservoir is full. In another projected development of 250,000 hp., less than 2 per cent of the land belongs to the government, and yet if the project is developed in such a way as to omit this 2 per cent, there would be a large loss in potential power. It would be criminal not to develop the full amount of power, and yet the obligation that would result under present rules and regulations of the departments would prevent financing the project. Mr. Merrill had previously suggested the following amendment to the bill to cover such cases as Mr. Britton spoke of.

"In issuing licenses for a part only of a complete project, or for complete projects of not more than 50 hp. capacity, the commission may, in its discretion, waive such conditions, provisions, and requirements of this act as it may deem equitable in the circumstances."

Mr. Britton laid stress on the necessity of hydroelectric development as a measure for conservation of coal or oil—resources which are destroyed when used once, as against the perennial and inexhaustible use of waterpower. He showed that the licensee can get only a fair return on his investment, and not even that unless he makes a success of the venture. In the latter case the government has an opportunity to recapture the project, and perhaps turn it over to a municipality.

Mr. H. T. Freeman of the Connecticut River Company showed the necessity for government action if such projects as those of his company are to come to fruition. He was asked if a waterpower trust existed in Connecticut, and replied that, on the contrary, there was the keenest competition.

Mr. John J. Harris, president of the Big Horn Canyon Irrigation & Power Company, Montana, described his project, which combined the features of power development, flood control, transportation and irrigation. He thought that local organizations of men with small resources might be handicapped by the provision of the bill allowing only three years for preliminary work on a project. He showed the committee what such preliminary work meant to his concern, which had been engaged for six years.

Mr. Charles N. Chadwick spoke in behalf of House Bill 9681, which seeks to provide for a broad administration of national water resources. It calls for a national board of water conservation to study rainfall, flood control, navigation and power development. Mr. Chadwick felt that this bill affords a better opportunity for broad treatment of the subject than does the administration water-power bill.

Mr. C. F. Kelley, counsel for the Montana Power Company, said that the Administration bill was generally acceptable as a measure that would encourage the development of water-power. He objected to recapture on the repayment of "net investment" to the licensee, and asked for "just compensation." Mr. Charles E. Stuart of the United States Fuel Administration told the committee of the efforts of the Administration to conserve fuel.

Mr. A. P. Morrison of the Electro Metallurgical Company, Niagara Falls, spoke from the viewpoint of the large user of power, to whom stability of service and rates were of prime importance. He felt that such consumers were not sufficiently protected in the bill. Their investment might easily be greater than that of the licensee, and yet at the expiration of the license they might be subject to readjustments in rates that would be prohibitive.

Mr. A. H. Houghton of the Conservation Committee of New York thought there would be some conflict between the Administration bill and the New York laws, and suggested amendments. The term of five years for the executive officer of the federal commission should be changed to ten or fifteen years. Mr. William B. Matthews of Los Angeles, which has its own municipal plant, said that a license to a municipality should be perpetual. The federal commission should not have jurisdiction over rates and service of a municipal corporation where power is used for state or municipal purposes.

Secretary Lane Advocates Immediate Development

Secretary Lane of the Interior Department was an important witness toward the close of the hearings. He pointed out that there is still on the books a statute under which revocable permits are granted, but that the men who have money to invest in water-power propositions are not willing to allow any official to say when the investment they have made shall be thrown to the winds. The result, he said, has been that we have stood for five years almost entirely without development of one of our great resources.

The secretary then cited the interdependence of the West and the East in water-power development. As an example he gave the recent action of the Anaconda Copper Mining Co. in undertaking the manufacture of ferromanganese. This was made possible by the development of water power in Montana near deposits of low-grade manganese ores. The effect of this single development had been to release shipping formerly used in bringing manganese to this country, but now available for war business. Furthermore, ferromanganese manufactured in Montana was used directly in the industries of Pittsburgh.

"If we had money enough," he continued, "if this were not a time of war, if we could think in the terms

of money that we are now thinking in, or if, four or five years ago, Congress had been willing to expend hundreds of millions of dollars in the development of water power as it is forced now to spend billions of dollars for war, it would be a wise thing to put a large part of the public revenues into such projects where they are found to be needed.

Government Ownership Feasible

"I have no doubt in my own mind but that such schemes as water-power schemes are perfectly practicable from a governmental standpoint, no matter what your sympathies may be respecting government ownership, as a rule, of large utilities. A thing that is as well standardized as a water-power scheme can be operated successfully by the Government; but I do not take it that this is a practicable proposition at this time, nor probably will it be for many years to come, and it is necessary that there should be real development, and that soon." Mr. Lane elaborated his point of view in regard to the impracticability of devoting Government funds at this time to the building of water-power plants by discussing the immense demands being made upon the treasury now and in prospect.

Answering questions by Chairman Sims, Secretary Lane said if there is a determination by Congress that there shall be water-power development, for instance, along the Columbia River, or the Snake River, or the Colorado River, for the production of low-grade manganese, or for the development of nitrates, either for gunpowder or for fertilizer, and such works could not be financed, that "it is the duty of the Federal Government at this time to help out the proposition and put it on its feet." He added: "I am not sympathetic generally with the idea of having the Government lend money to private enterprises, because it is a hard thing to get it back. But I am very much in sympathy with the Government doing what it pleases with its own money, provided it knows where it is going and what it wants and how that money can be properly handled; and I am not afraid at all of the Government undertaking the development of the water-power propositions, because we have had some experience with them in the Reclamation Service. The Salt River proposition which I have turned over to the water users is practically paying its own way now out of the power developed at the Roosevelt dam. That was a venture at the time. All of these propositions are gambles. That is one reason why a man who puts his money into a water-power project has got to have very real consideration. He is a developer, and every man who is a pioneer of any kind takes the risk, and for his risk he ought to be compensated."

In reply to a question as to whether it will be possible for water-power plants to be built in time to be of service before the war is over, Secretary Lane said: "I have no expectation that this war will be over before water-power projects such as many that we know of can be developed. I think you have got to look at that thing with a long range."

Expansion Predicted in Electrochemical Industries

Secretary Lane predicted a great expansion of the electrochemical industries of the United States. "We ought to appreciate more fully now that after this war is over there will be the necessity of larger electrical development than we have ever had before in connection with the chemical industries of the United States.

"We have never been a chemical nation, and that side of our scientific development has been overlooked. Germany has been the chemical nation of the world. We are now taking that up, and probably there is more interest today in chemistry in the United States than there has ever been before. We have in Washington today hundreds of chemists working in connection with the Bureau of Mines and the Ordnance Department. They have been gathered from all parts of the country. A great many of them are Germans, many of them educated abroad in German institutions, showing how far ahead Germany has been in this particular line of science. It is quite manifest to me that there has got to be very large hydroelectric development if we are going to develop to the highest degree along the lines of chemistry. Perhaps the best sphere for a young man for the next twenty-five years will be as an electrochemical engineer in the United States. The water powers ought to be developed now, not only with the idea of taking care of a process that is a commercially successful proposition, but for the purpose of experimenting and discovering what can be done. We ought to foster that kind of thing."

United States Chamber of Commerce Referendum on Water-Power Legislation

The Chamber of Commerce of the United States announces the results of a referendum to more than 1000 commercial organizations on a series of recommendations relating to water-power development. The following recommendations were approved by sweeping majorities:

> That federal legislation encouraging the development of waterpowers should at once be enacted; that authority to grant permits should be vested in an administrative department; that the permit period should be at least fifty years, any shorter period being at the applicant's option; that tolls should attach only to use of public lands or benefits derived from headwater improvements; that permittees should be entitled to acquire the right to use public lands forming only a small and incidental part of the development; that recapture should be exercised only upon payment of fair and just compensation; that, if recapture is not exercised, the investment of the permittee should be adequately protected; that rates and service should be regulated by State commissions where the service is intrastate, with federal regulation only where several States are directly concerned and do not agree, or there is no State commission; that if any jurisdiction to regulate the issuance of securities is exercised it should be solely by the State; that no preference should be granted as between applicants amounting to a subsidy from the Government creating unequal competition.

These provisions are practically contained in the Administration bill now before the special waterpower committee of the House. They were regarded as the vital points on which there might be a difference of opinion, and in sending out the referendum the Chamber was careful to present arguments for and against each of the ten items. Consequently the vote may be considered indicative of intelligent opinion formed by the business men of the country after a careful study of the subject. Some negative votes were cast on each item, but the number was insignificant and the net result may be looked upon as a unanimous demand for the development of water power and approval of the proposed procedure.

Standardization of Rare-Metal Thermocouples*

By PAUL D. FOOTE, T. R. HARRISON and C. O. FAIRCHILD
United States Bureau of Standards

MANY technical industries use such extensive installations of pyrometer equipment that it is frequently desirable to place the general supervision and maintenance of this equipment in the hands of a technical expert. The duty of this engineer and his assistants is to calibrate the instruments, check frequently the accuracy and constancy of the pyrometers, make small repairs, construct thermocouples, and install new apparatus when required. He should be familiar with all methods of temperature measurement, temperature control, etc., and various chemical and metallurgical processes, so that he may suggest advisedly new methods and improvements in temperature measuring apparatus for the particular process in question.

A man of the required ability will necessarily command a good salary, but it has been the experience of many companies that it is poor economy to place work of this character in the hands of inexperienced men. If it is believed that a perfect working system of temperature control can save a certain plant any considerable sum each year, a fair percentage of this amount can be profitably spent in securing a competent, technically-trained man and in equipping a modern laboratory for the maintenance of the pyrometer installation. With the proper organization and equipment, exceedingly valuable investigational work may be carried on, new opportunities will be found for increasing the value and uniformity of the finished product and the cost or production may be lowered by reducing the number of failures to a minimum.

Type of Tests Performed in the Industrial Laboratory

The modern industrial plant employs various types of pyrometers including the high-temperature mercury thermometer, the resistance thermometer, the radiation pyrometer, the optical pyrometer, and the thermocouple, etc. Each type of instrument has its advantages for various processes. The calibration, upkeep and use of each class of instrument should be carefully considered.

The present paper deals with the laboratory side of one phase of this problem, namely, thermocouple installations. This is, however, probably the most important subject with which the pyrometer laboratory has to deal. The calibration of optical and radiation pyrometers requires rather elaborate equipment and is so susceptible to errors that this type of testing is usually not advisable for the ordinary technical laboratory. It is better to send such instruments to the maker or to the Bureau of Standards for calibration. Furthermore, the number of calibrations of optical or radiation pyrometers required per year by any one company is, in general, comparatively small since these instruments do not deteriorate with use as do thermocouples. A single calibration of a good optical or radiation pyrometer should hold for years if the instrument is properly cared for. On the other hand, the calibrations of the thermocouples must be repeatedly checked, for contamination and use may alter the temp.-e.m.f. relation, and the life of base metal couples is frequently so short that the calibration of new couples becomes a serious problem in the case of large installations.

Thermocouple testing may be divided into two general classes, primary standardization and secondary standardization. In primary standardization the thermocouple is calibrated directly in terms of certain fixed temperatures, defined by the melting or freezing points of a series of chemically pure metals. In a secondary standardization the couple under test is compared with another couple which has been calibrated as above. Primary standardization is not recommended for most industrial laboratories, as it requires a considerable amount of extra apparatus and laboratory technique. The Bureau of Standards undertakes work of this character for a nominal fee and recommends that the industrial laboratory maintain at least two standard rare-metal couples, which may be submitted to the bureau at intervals for a primary calibration. All the couples are then calibrated in the industrial laboratory by comparison with these standards. However, a number of companies prefer to do their own primary standardization and for this reason the best methods for primary calibrations as well as secondary calibrations are discussed below.

Standardization of Rare-Metal Couples

The rare-metal couple may be purchased completely mounted in a porcelain or quartz tube with the cold junction arranged to operate at room temperature or at the temperature of melting ice. The latter method is preferable for the highest accuracy, but the former method is usually sufficient for most requirements. A suitable ice box is described later.

If desired, the thermocouple wire may be purchased from the platinum refiners and made into couples in the laboratory. One wire should be platinum and the other an alloy of 10 per cent rhodium with platinum, both of the highest possible purity. For general work, wires 0.5 mm. or 0.6 mm. in diameter and 100 cm. long serve satisfactorily. A shorter length may be used if the cold junction is operated at room temperature or in connection with the compensating leads to be described in a later article in a paragraph on cold junctions.

The hot junction is formed by fusing the two wires in an oxy-gas flame or small electric arc. With a little practice a neat joint can be made which should be in the form of a bead about 1 mm. diameter. The wires are threaded through two-hole porcelain insulators and placed inside of a thin-walled protecting tube of quartz or of porcelain, glazed on the outside only. The two

*The first of a series of two articles dealing with the pyrometer laboratory for industrial purposes. The second article will deal with base-metal thermocouples

free ends of the couple are mounted in the ice box (See section on cold junction ice box) and from this point copper leads are carried to the potentiometer.

ANNEALING

Before standardization the couple should be removed from the mounting and the entire length of wire electrically annealed for a few minutes at about 1500 deg. C. This treatment eliminates the electromotive forces which otherwise would be developed between the hard and soft portions of the wire. When rare-metal couples have been contaminated by long continued use they may be often restored to their original condition by annealing for an hour or more at this high temperature. Impurities, such as iron oxide, which have accumulated on the surface of the wires may be removed by 50 per cent nitric or hydrochloric acid. In case long-continued alternate heating and treatment with acid fail to restore sections of the couple, these badly contaminated portions should be cut out and the couple fused together again with as small a junction as possible.

For annealing electrically the couple is suspended between two binding posts and sufficient current passed through it to raise the temperature of the wire to about 1500 deg. C. A couple made of wires 0.6 mm. in diameter requires about 14 amp., 0.5 mm. about 12.5 amp. and 0.4 mm. about 10 amp.

In general the contaminated portions do not glow as brightly as the more pure sections of the wire. If the wire is not badly contaminated the darker spots will gradually disappear. If more extreme local treatment is required, the contaminated portions may be wound into a small spiral and the couple heated as before. The coiled portion of the wire loses less heat per unit length by radiation and hence can be maintained at the desired temperature while the rest of the wire is heated to a dull red. Usually foreign matter produces a gray or dark appearance of the wire when cold, and these contaminated sections are stiffer than the uncontaminated wire.

While couples may be often restored to their original condition by annealing, the disappearance of the gray spots on the wire does not prove absolutely that the couple is free from contamination. The absence of contamination is shown, however, by a homogeneity test. Where high accuracy is required a homogeneity test should be made.

HOMOGENEITY TEST

For work of precision each wire of the couple must be uniform in chemical composition and physical condition throughout its entire length. The magnitude of the e.m.f. developed by the couple depends upon the composition of the couple in the region of the temperature gradient. The e. m. f. developed by an inhomogeneous couple is not necessarily a measure of the temperature of the hot junction. In fact it is a measure of the temperature of the hot junction only when the region of inhomogeneity lies entirely outside of the region of temperature gradient. Such a fortunate condition would be obtained very rarely in practice.

Suppose, for example, in a furnace 40 cm. long, that the temperature is uniform and at 1000 deg. C. over the central 20 cm. of the furnace and that the temperature drops, linearly with distance, to 0 deg. C., over the remaining 10 cm. on each side. Omitting consideration of conduction losses, a homogeneous couple would show the true temperature of any desired portion of this furnace, and the temperature indicated would be that corresponding to the position of the hot junction of the couple.

Consider the use of an inhomogeneous couple in which the wires are badly contaminated for a length of 5 cm. from the hot junction. This couple would give the correct temperature of the central portion of the furnace when immersed to any depth between 15 and 30 cm. because for such depths of immersion the inhomogeneous portion of the couple lies wholly within the region of temperature uniformity. It would not be possible to measure with this couple the temperature of any portion of the furnace less than 15 cm. from the outside because the region of inhomogeneity would lie in the region of temperature gradient. Under such conditions the couple acts as a compound or differential couple and it is impossible to predict how much in error its indications may be since the magnitude of the error depends upon the amount of contamination and the steepness and location of the temperature gradient.

The above example illustrates the fact that the reading of an inhomogeneous couple depends upon the depth of immersion and does not, except by accident, indicate the temperature of the hot junction. It would be impossible to measure, by means of an inhomogeneous couple, the temperature of any portion of a furnace which was non-uniformly heated, unless the couple were calibrated in the position used.

For a homogeneity test a short length of each thermocouple wire is selected as a standard reference specimen. These lengths may be cut from the uncontaminated cold-junction ends of the couple and one set may be used repeatedly for various couples of the same type. One end of the standard wire (for example the pure platinum wire) is touched to a section of the corresponding wire of the thermocouple and the e.m.f. is observed between the cold-junction end of the thermocouple wire and the free end of the standard wire when the point of contact between the standard and the thermocouple is heated to some convenient high temperature, maintained constant.

The point of contact of the two wires is then moved to a different section of the thermocouple wire and the process continued until the platinum wire of the thermocouple is completely explored. The process is repeated for the alloy wire of the couple, except that in this case the speciment of the alloy wire is used as the standard.

If e is the maximum difference in microvolts between the two readings of e. m. f. made along one wire of the thermocouple and s the value of the thermoelectric power for the couple (microvolts per degree of temperature) then the maximum error usually possible in the use of the couple due to inhomogeneity of this wire is e/s in deg., provided the temperature of the hot junction in general use does not exceed that employed in the homogeneity test.

If the temperature difference between the hot and cold junctions during the homogeneity test were $t_1 - t_2$, and during the actual use of the couple $t_1' - t_2'$, the maximum error possible in the use of the couple, due to inhomogeneity of this wire, is approximately $\frac{t_1' - t_2'}{t_1 - t_2} \frac{e}{s}$ degrees. Similar conditions hold for the other wire of the couple.

The effects of inhomogeneity in both wires may be either subtractive or additive so that it is evident that to quantitatively correct temperature readings for errors due to inhomogeneity is practically impossible. Merely qualitative results can be obtained from tests of this nature. If the variations in e.m.f. observed during the homogeneity test are less than 5 microvolts for $t_1 - t_2 = 500$ deg. C., the couple can be relied upon for precision work. If certain sections of the couple show larger e. m. f. these sections should be treated by annealing until their condition is satisfactory, or should be cut away in case they cannot be brought to a proper condition.

The point of contact between the couple wire and the standard wire may be heated by a Bunsen flame, but a more satisfactory method is as follows: The heater consists of a glass (preferably pyrex glass) T tube having the top and leg of the T wound with resistance wire through which sufficient current is passed to heat this tube to about 400 deg. C. One of the wires of the thermocouple is threaded through the top of the T and the standard wire is brought into contact with the couple by threading it through the lower part of the T. The end of the standard wire is bent into a small hook through which the couple passes, sufficient tension being given to the standard wire to secure good electrical contact with the couple. The free ends of the

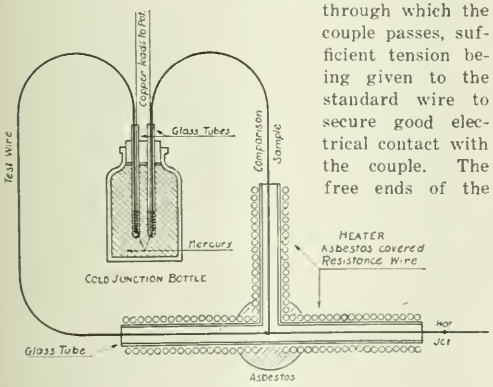


FIG. 1. APPARATUS FOR HOMOGENEITY TEST OF RARE METAL COUPLES

couple wire and the standard are maintained at the same temperature by use of a cold-junction box.

The cold-junction box may consist of a small bottle of mercury into which dip two small glass tubes closed at the lower end. A few drops of mercury are placed in each tube and the free end of the couple wire is inserted into one tube and free end of the standard into the other tube. Copper wires making contact with the platinum wires by means of the mercury inside the tubes lead to the millivoltmeter or potentiometer. The copper and platinum must not come in electrical contact except in the mercury. Readings of e. m. f. are made for various points of contact along the couple by pulling the couple through the T tube and allowing a minute or so for temperature equilibrium at each new position. Figure 1 illustrates the apparatus used for homogeneity tests.

The Laboratory Potentiometer:

In precision thermocouple calibration a potentiometer especially designed for this type of work should be used.

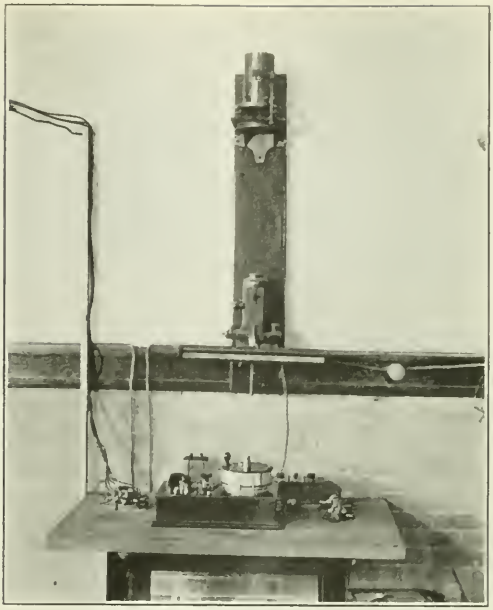


FIG. 2. A LABORATORY POTENTIOMETER AND ACCESSORIES

Figure 2 illustrates a complete potentiometer installation, including galvanometer and reading scale. The wiring diagram is given in Figure 3.

In order to eliminate the effect of accidental thermal e.m.f.'s developed in the instrument itself two double-pole double-throw switches are used, one in the main battery circuit and one in the e. m. f. circuit. Readings are made with the two switches thrown first in one direction and then in the other direction. In one case the parasitic e.m.f.'s arising in the potentiometer and galvanometer are additive to that of the couple and in the other case they are subtractive, whence a mean of the two readings gives the true e. m. f. of the thermocouple circuit. In comparing the e.m.f.'s of two or more couples, readings should be taken in the following order and the final means obtained, used as the calibration data.

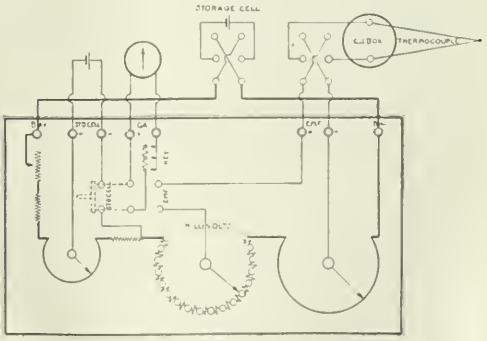


FIG. 3. WIRING DIAGRAM OF POTENTIOMETER INSTALLATION

Position of Switches	Couple I	Couple II	Couple III
Normal	1	2	3
Reversed	6	5	4
Normal	7	8	9
Reversed	12	11	10
	mean emf.	mean emf.	mean emf.

Care should be taken that the battery switch is in the normal position when balancing the instrument against the standard cell. The main battery of the potentiometer should be a 2-volt storage cell of about 50 amp. hr. capacity and should be charged every three months. Details in regard to the use and care of a potentiometer are given in the instruction manual furnished with the instrument.

Cold-Junction Ice Box

A satisfactory ice box is obtained by fitting a small battery jar with a fiber or hard rubber cover. Through the cover are inserted several small glass tubes closed at the lower end, two tubes for each couple used. A few drops of mercury are placed in each tube and the battery jar is kept filled with clean ice shaved or ground into a wet snow.

The cold junction ends of the couples are inserted, one in each tube, and copper wires lead from the mercury to the potentiometer. The copper wires should be insulated from the couple wires throughout the length of the glass tubes except where they dip into the mercury. This precaution is very important, for if the copper and platinum (or alloy wire) are in electrical contact at the top of the glass tubes, the whole value of the ice box is lost.

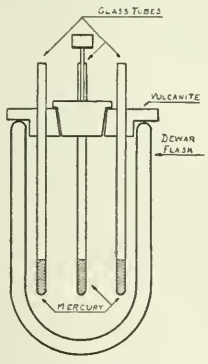


FIG. 4. THERMOCOUPLE ICE BOX

The glass tubes should be kept clean and dry inside. A little moisture and dirt at the bottom of the tube will form a galvanic cell giving a large e. m. f. This trouble is easily detected by the rapid change in e. m. f. immediately after closing the potentiometer key, due to the polarization of this small cell. It is desirable, but not necessary, to replace the battery jar by a Dewar flask or thermos bottle having a large mouth, since the ice melts more slowly in this form of container. Figure 4 shows a diagrammatic sketch of an ice box suitable for thermocouple work.

Calibration of Primary Standards

When a crucible of pure molten metal is allowed to cool, the cooling curve obtained by plotting temperature of the metal versus time is continuous until the freezing point (or transformation point) is reached. During freezing the metal gives out enough internal latent heat to supply the losses due to radiation and convection, and the temperature of the metal remains constant until all the metal has frozen. In this region of the cooling curve, the curve is parallel to the time axis. After the metal has frozen it cools in a somewhat similar manner as when completely molten. Figure 5 shows cooling and heating curves for several metals.

The freezing point of copper (1083 deg. C.) is clearly indicated by the flat portion of the second curve. On heating a metal the temperature gradually increases with time until the melting point is reached. The temperature of the metal then remains constant, as shown in Figure 5 until all the metal is melted, after which the temperature again increases with time.

The temperatures at which melting and freezing occur are identical for pure metals. When molten antimony is allowed to cool the temperature usually falls below the freezing point before the metal starts to freeze, a phenomenon known as under-cooling. When any of the metal starts to solidify, however, the temperature immediately rises to the freezing point as shown in Figure 5, unless the under-cooling has proceeded too far. Under-cooling may be greatly reduced by stirring the metal for an instant just as the freezing point is approached.

Aluminium does not appear to have as well defined a melting or freezing point as do many other metals. The material is "pasty" over a small temperature range. This may be due to the presence of impurities and is probably not a characteristic of the pure metal.

In the primary calibration of rare-metal couples use is made of the type of cooling and heating curves above described. The couple, properly protected, is immersed in the molten metal which is then allowed to cool slowly. The e. m. f. of the couple is observed as frequently as possible and the time noted for each observation. These values are plotted and the e. m. f. corresponding to the flat portion of the cooling curve is the e. m. f. at the freezing point of the metal. A similar process may be carried through by melting the metal.

The temp.—e. m. f. relation for the platinum, platinum-rhodium couple has the following form: In the

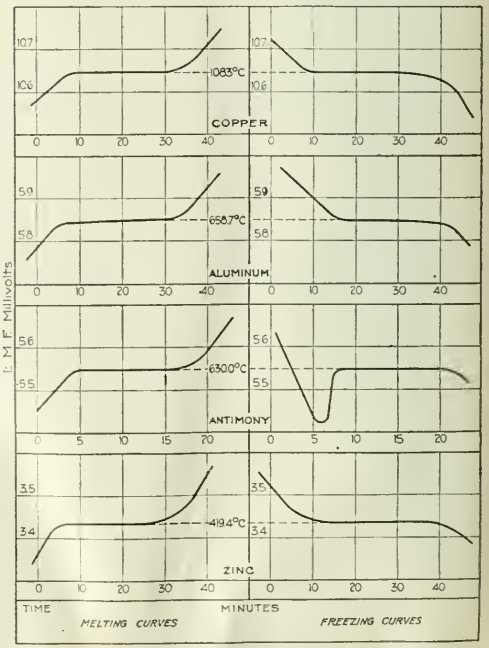


FIG. 5. TYPICAL HEATING AND COOLING CURVES

temperature range 300 deg. to 1200 deg. C., $e = a+bt+ct^2$ where e=e. m. f., t=temp. deg. C. of the hot junction of the couple (cold junction= 0 deg. C.), and a, b, and c are constants. Three standard points are required to determine a, b, and c for any particular couple. These fixed temperatures may be the melting or freezing points of zinc 419.4 deg. C., antimony 630 deg. C., or aluminium 658.7 deg. C. and copper 1083 deg. C. The metals must be of the highest possible purity. This is especially the case with antimony, which is very difficult to obtain in sufficient degree of purity. The Bureau of Standards furnishes standard samples of zinc, aluminium, and copper (also tin, see Circular No. 66), with certified melting points. Aluminium of the highest obtainable purity is recommended in preference to antimony for the industrial laboratory. The following shows the method of obtaining the constants a, b and c:

OBSERVED CALIBRATION POINTS

Metal	Temperature	emf.
Zinc	419.4°C	3.436 millivolts
Aluminium	658.7	5.839
Copper	1083.	10.561

Whence, from the above equation it follows that:

$$3.436 = a + (419.4)b + (419.4)^2c.$$
$$5.839 = a + (658.7)b + (658.7)^2c.$$
$$10.561 = a + (1083)b + (1083)^2c.$$

These three equations are solved for a, b, c, giving a=—0.3240, b=+0.008277, c=+0.000001638. The final equation for this couple thus becomes:

$$e = -0.3240 + 0.008277t + 0.000001638t^2$$

where e is the e. m. f. in millivolts corresponding to a hot-junction temperature of t deg. C., and a cold junction temperature of 0 deg. C. From this equation e may be computed for various values of t deg. C., (for example 300 deg. C.=2.306 millivolts; 350 deg. C. =2.774; 400 deg. C.=3.249; 1200 deg. C.=11.967, etc.) and a curve or table of e versus t deg. C. may be constructed. Using this curve or table one may readily find the temperature corresponding to any e. m. f. observed in the future use of the couple.

The above equation serves to determine the temperature scale in the interval from 300 deg. C. to 1200 deg. C. An entirely different equation must be used for points below 300 deg. C. For discussion of this see Burges and LaChatelier "Measurement of High Temperatures." At temperatures higher than 1200 deg. C. the following corrections must be added to the temperatures given by the above equation. These corrections apply for all platinum—ninety platinum—ten rhodium, thermocouples.

Temperature computed from parabolic equation	Correction to add
1200°C	0°C
1300	2
1400	6
1500	14
1600	25
1700	37

The standard metal may be used in an Acheson graphite crucible (Dixon graphite is also satisfactory for copper) the inside diameter of which is slightly less at the bottom than at the top. Convenient inside dimensions are about 5 cm. diameter and 15 cm. deep. For use with the 50 cm. 3 metal samples furnished by the Bureau of Standards a crucible 3.5 cm. inside diameter and 8 cm. deep is recommended. Crucibles should be fitted with a cover having a small hole in the center through which the couple is inserted. The crucible may be heated either in an electric or gas furnace. Figure 6 shows a convenient form of electric furnace. The bottom of the furnace must be tightly closed with asbestos wool as the slightest current of air will rapidly oxidize the crucible. If this simple precaution is omitted, in a very short time the bottom of the crucible will burn completely away allowing the metal to run out and become contaminated. Also the furnace will be seriously damaged by the molten metal.

If a gas furnace is used the crucible should be placed inside a length of iron pipe, capped at the bottom, and the space between the crucible and the pipe should be filled with powdered or flaked graphite. Instead of an iron pipe, a larger crucible of Dixon graphite or fireclay may be used. In all cases the top of the crucible and the surface of the metal should be covered with 2 or 3 cm. of powdered or flaked graphite. This is especially important with copper, as the oxide of copper formed on exposure of the hot metal to the air is soluble in the metal and thus lowers the melting point to an appreciable extent.

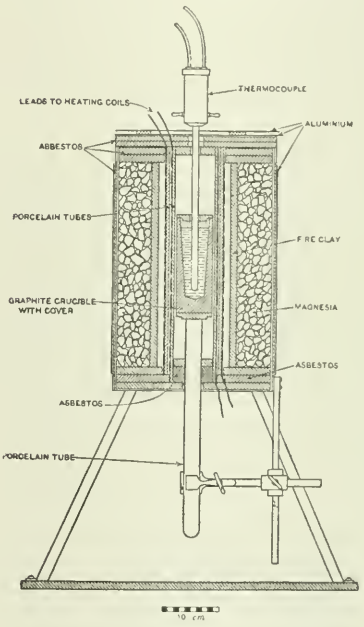


FIG. 6. ELECTRIC FURNACE FOR STANDARDIZING THERMOCOUPLES BY MELTING-POINT METHODS

PROTECTING TUBE FOR RARE-METAL COUPLE

The thermocouple must not come in direct contact with the molten metal or metallic vapors. A suitable protecting tube is of porcelain glazed on the outside and closed at the lower end. The diameter of the tube may be 1 cm. or less and the walls should be thin. The couple wires are again protected and insulated from each other by small porcelain insulating tubes, or by the standard two-hole porcelain tubing sold for this purpose.

It is good practice to remove the couple and insulators from the outside protecting tube when immersing the latter in the molten metal as frequently the tubes are broken in this operation. This precaution saves the couple in case such an accident takes place. The procedure is therefore as follows: Hold the pyrometer tube above the furnace in the heated air until it takes up this temperature. Gradually lower it into the furnace

until the top of the crucible is reached. When thoroughly heated gently immerse it in the metal. Observe that the tube is not broken. If in doubt insert a small porcelain tube inside the pyrometer tube. If the outer tube is broken the small tube will be discolored or contaminated with the metal. Another method of detecting a broken tube is to pull it out of the metal and if intact replace it before it has had time to cool. After having determined that the pyrometer tube is good, insert the thermocouple. This should be done very slowly as the rapid insertion of the cold thermocouple may break the protecting tube. After the metal has frozen the protecting tube should be withdrawn or the furnace should be immediately heated for a melting point determination. An immersed tube which is allowed to cool with the metal far below the melting point is usually broken. For a small temperature range below the melting point the tube can be readily withdrawn.

Either glazed porcelain or fused quartz (silica) protecting tubes may be used in this work. With aluminium, however, the protecting tube must be itself protected from the metal. This is easily done by making a tubular sheath of Acheson graphite, with walls about 1 mm. thick, which slips over the quartz or porcelain tube. It is better to have one set of tubes for each metal, but when necessary to use the same tube in various metals this can be done if care is taken to thoroughly clean the tube with nitric and hydrochloric acid. The greatest care should be exercised to see that no dirt of any kind gets inside the pyrometer tubes. Dust or carbon inside the tubes, when heated, forms a reducing atmosphere which acts upon the silica, freeing silicon which rapidly attacks the platinum.

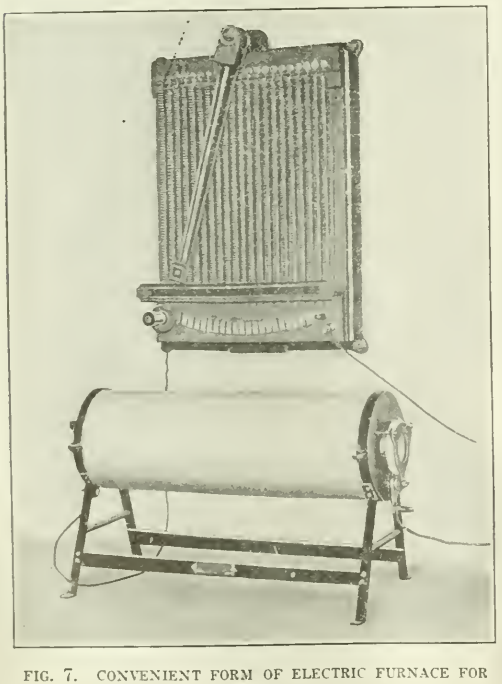


FIG. 7. CONVENIENT FORM OF ELECTRIC FURNACE FOR INTERCOMPARING RARE METAL COUPLES

Secondary or Comparison Calibration of Rare-Metal Couples

The secondary method, as follows, is recommended for industrial laboratories. One or preferably two rare-metal couples of wire about one meter in length and 0.6 mm. in diameter are maintained as primary standards. These couples should be submitted to the Bureau of Standards for test and certification at intervals depending upon the amount of use to which they are put, or whenever contamination is suspected. The couples to be tested are compared with these standards. Suitable electric furnaces for such comparison tests are now available, designed to operate on either 110 or 220 volts and may be obtained complete with adjustable rheostat for regulating the current, as shown in Fig. 7. The furnace consists of a porcelain tube wound with platinum foil, surrounded by a larger porcelain tube around which is packed thermal insulating material. A convenient size of heating tube is 1 in. by 18 in., but larger sizes can be secured if desired. The furnace should be kept clean and should not be used for testing base-metal couples, annealing iron rods, or other processes likely to cause contamination.

The rare-metal couples to be calibrated are removed from the protecting tubes and insulating tubes and annealed as described previously. The insulating tubes are then replaced and the couples are tested without the protecting tubes, if the furnace is clean. The hot junctions of all the couples, the standard couple and the couples under test, are connected together with as good thermal contact as possible. The junction may be fastened together with a small platinum wire and then wrapped with platinum foil. Since the couple wires are thus in electrical contact at the hot junction, they must not be allowed to touch one another at any other point. The use of platinum foil around the hot junction is to reduce temperature gradients to a minimum. If the couples are tested in the protecting tubes, this precaution becomes still more important.

The cold junctions of all the couples are maintained at 0 deg. C. If three couples are being compared with one standard, the readings should be taken in the following order:

Reversing Switch	Standard	No. 1	No. 2	No. 3
Normal	1	2	3	4
Reversed	8	7	6	5
Normal	9	10	11	12
Reversed	16	15	14	13
Means				

The means of the observations on each couple are taken and the temperature is obtained from the reading of the standard couple. Several calibration points are made in this manner in the range 300 deg. C. to 1200 deg. C. These are plotted, temp. vs. e.m.f. and a smooth curve is drawn through the experimental points for each couple. If it is inconvenient or undesirable to use a cold junction temperature of 0 deg. C. for the couples under test, any other constant temperature may be employed. This can be measured by means of a mercury thermometer. It is nearly as essential to know the temperature of the cold junction as that of the hot junction since the magnitude of the e.m.f. observed depends upon both temperatures.

A subsequent article will deal with the calibration of base-metal couples and other general pyrometer laboratory data.

The Design and Operation of a Small Kjellin Furnace*

Manufacture of Electric Steel for Stamp-Mill Shoes and Dies on the Witwatersrand, South Africa

By GEORGE H. STANLEY and W. BUCHANAN

As one result of the war and consequent restriction of imports, the mining industry in South Africa found it imperative to utilize to the fullest extent all local resources in plant and material to supply its urgent necessities. Among the latter, obviously, stamp-battery shoes and dies occupy a prominent place, a regular supply to the extent of about 7500 tons annually being essential to the conduct of gold milling. In order to consider the possibility of the manufacture of shoes and dies locally, a committee was appointed in February, 1916, at the instance of the Chemical, Metallurgical and Mining Society of South Africa.

This committee reported that it was of opinion that such manufacture was possible by utilizing existing accumulations of scrap shoes and dies, and strongly recommended that it be undertaken at once in view of increasing shortage and rapid rise in price.

After considering various means of production, such as forging scrap, or melting in coke or gas-fired crucibles, open-hearth furnaces or electric arc furnaces, it appeared that an electric induction furnace of the Kjellin type was most practicable. It was practicable to construct it locally from existing material and of the required capacity. The Victoria Falls and Transvaal Power Company could supply current suitable with some modification for a small furnace, and requiring comparatively inexpensive electrical arrangements. Alternatively, suitable generators, to be motor-driven, were available. This type of furnace does not, however, lend itself to working up miscellaneous scrap in the same way as an arc (or combination induction-resistance) furnace, but this was not contemplated at the immediate time. It requires no electrodes, and could be constructed of locally available materials in from six to eight weeks. Unfortunately, 50-cycle current requires such thin furnace walls that the thermal efficiency is reduced by large radiation, and therefore large furnaces are impossible. Again, the best channel section is narrow and deep, which requires small-sized scrap. It was therefore necessary to install a frequency converter, producing 10 to 15-cycle current.

It is useful to compare the economic efficiency of the induction furnace, including a frequency converter, with that of the arc type plus electrodes. A modern motor-generator of about 200 kw. capacity, converting three-phase, 50-cycle supply into single-phase at low frequency would have a full load efficiency of at least 80 per cent, and since it requires about 800 electrical units to melt one ton of steel, the loss by transformation is 200 units, which at, say 0.6d. (1.2c.) per unit amounts to 10s. ($2.40) per ton of castings. The consumption of graphite electrodes in furnaces of the Heroult type is at least 15 lb. per ton of steel melted, while in the Stassano and Rennerfelt types, where the electrodes are not in contact with the metal or slag, it is about 10 lb. The price of graphite electrodes has very considerably advanced, and is now at least 1s. ($0.24) per lb., so that the cost is 15s. ($3.60) and 10s. ($2.40) per ton of steel respectively. The capital cost of induction furnace with converter would be about the same as that of the corresponding arc furnace, with its transformer, and electrode regulating gear.

Material Available

There is at every mine an accumulation of worn and scrapped shoes and dies amounting in the aggregate to several thousands of tons, and on the average about 15 per cent of the new weight of shoes and dies is ultimately discarded as scrap. Much of this has been utilized for such purposes as flooring, but is mostly recoverable if necessary. There is consequently many months' supply for the furnace installed, but it is also possible to utilize other scrap of similar composition and suitable shape, difference in composition being rectified by suitable additions. Manganese is available in high manganese-steel scrap, silicon and carbon in selected cast-iron pig and scrap, carbon as gas-retort carbon and charcoal, while aluminium is stocked in considerable quantity.

Analyses of imported shoes and dies are given in Table I.

Table I

	A. Kowel Die	Orenstein-Koppel Die	Orenstein-Koppel Shoe	Orenstein-Koppel Shoe	Fraser & Chalmers Die	Cammell-Laird Die	J. J. Colver Die	J. J. Colver Shoe	Sanderson-Newbolt	
									Shoe	Die
Carbon	915	815	818	772	865	930	930	700	79	96
Silicon	250	267	244	206	225	154	211	223	24	17
Manganese	633	441	385	792	357	672	516	504	80	81
Phosphorus	028	055	014	060	028	053	027	016	014	010
Sulphur	060	055	035	056	060	070	038	049	037	021

Plant Installation

It appeared probable that a furnace of about one ton capacity would be suitable. If this poured a heat of two-thirds of its contents three times per day, two tons of steel would be obtained, equivalent to 12 to 24 shoes and dies, depending on the individual weight. This is roughly 10 per cent of the total requirement and very probably could be considerably increased, possibly even doubled, by quicker working. This, at any rate, would put beyond question the suitability of the product, and enable working costs to be more nearly ascertained.

The furnace itself was constructed[1] as shown in Fig. 1, but with some slight modifications; the cores and yokes being built up of old transformer iron, and the primary winding, consisting of copper cable insulated with asbestos tape, being placed in a three-inch coil

*A combined abstract of two papers: Electric Furnace Manufacture of Shoes and Dies on the Witwatersrand, by Geo. H. Stanley. *Jour. Chem., Met.* and Min. Soc. of S. Africa, Sept., 1917, and The First Electric Steel-Melting Furnace in South Africa, by W. Buchanan. *Jour. S. African Met. of Elec. Eng.*, Sept., 1917. This part of the papers relates to operation. Features of design will be presented in a second article.

[1]Details of the design are given later in the article

space between the core and inner walls of the furnace. Between the inner wall and the coil itself a cylindrical shield of asbestos sheet was placed with the idea of protecting the coil in case of the molten steel breaking through the wall.

Instead of elaborate water-cooling arrangements, air circulation alone is depended on for cooling the coil, a ventilating cowl of asbestos millboard—not shown in the drawing—being placed over the center and connected to a chimney passing through the roof. At first a compressed air jet was used to increase the air velocity, but seemed to have no appreciable effect on cooling and was therefore discarded. This arrangement effects a very considerable simplification of design, and does not seem to be attended with serious drawbacks.

The body of the furnace is built up of special radial and rebated lumps (Fig. 2) tied over all with steel hoops, terminating in screwed ends passing through yokes, so that tightening or loosening could be effected. Any further iron or steel work being very undesirable from the electro-magnetic point of view, the plates between these and the brickwork were of monel metal—another feature believed to be novel—in fact, this alloy is used, replacing iron or steel, wherever desirable and possible in this furnace. To keep the power factor as high as possible, the interior wall was made 8 in. thick (plus, of course, the thickness of the lining), while the outer brickwork has a thickness of 9 in., in each case laid in fireclay. The cover bricks are of radial shape, 2 in. thick, and to prevent breaking or cracking are clamped as shown in Fig. 3 by means of monel metal rod flattened and bent over at the ends, and with screws put through so that they may be tightened up. A strip between them serves for lifting when required.

In the annular trough formed between the inner and outer walls the working lining of the hearth is placed. One of the initial difficulties was the selection of a suitable material for this lining. Knowing that reasonably pure magnesite occurred in the country, it was originally intended to construct the lining of calcined magnesite, but owing to the difficulty of satisfactorily calcining this material at the temperature under which it is to be used, the first lining was made by ramming ganister, prepared by grinding together pure quartz with a small amount of fireclay, round a sectional wooden template.

Operation of the Plant

After removing the template, which left an annular trough 16 in. deep by 5½ in. wide, the lining was allowed to dry naturally overnight and then warmed up by a fire bucket inside the central core space, and finally by burning wood on the hearth. Then, in order to further heat and start the furnace, coals of discarded wire haulage rope—again a novelty—were placed in the hearth, the iron yoke fitted into place and current switched on. However, as the temperature rose, the expansion of the ganister caused it to crack in several places and strip away from the brick of the inner wall. Attempts to repair gave no promise of success, so that the attempt was abandoned. Moreover, the wire rope became badly oxidized, particularly near the tap hole which had not been closed causing it eventually to break circuit. All the inner wall lining was therefore taken out and replaced by tar-chromite mixture, rammed by hot iron rammers, and a fresh start made with wire rope as before, but with a reducing atmosphere maintained by burning wood in the hearth. The temperature was raised very gradually for nearly three days till the rope began to melt, but with the unexpected result that since melting started at one point only, the melted metal at once dropped to the bottom of the hearth and broke circuit. Attempts to bridge the break by driving in iron bars and adding turnings, etc., were only temporarily successful, and finally fluid cast iron was obtained and poured into the furnace. This restored conductivity, but some of it solidified on top of the wire rope coil, hiding from view the hearth-bottom which, as subsequently appeared, contained a small quantity of fluid metal, while the solid top separated from it was only red hot and heated by radiation from that below. As a result, the temperature of the liquid

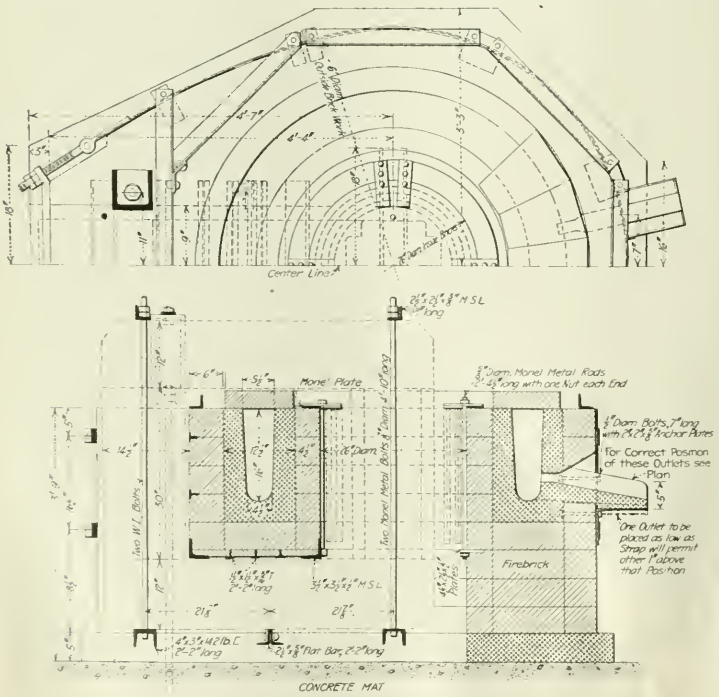


FIG. 1. PLAN AND SECTIONAL ELEVATION OF KJELLIN FURNACE

metal was so increased that the inner chromite lining was melted through and the metal escaped on the floor.

The corrosion had been considerably assisted by chemical action by the carbon and other elements in the iron reacting with the lining, so that the escaping metal was rich in chromium: it seems possible that this idea might be devoloped as a method for the pro-

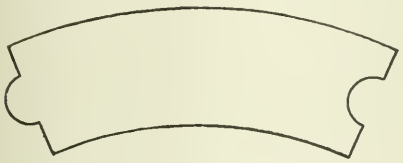


FIG. 2. FURNACE BRICK

duction of chrome alloys. Considerable damage was done to the coil and transformer iron, and while this was being repaired the opportunity was taken to obtain some of the magnesite bricks and have them ground down to prepare a fresh lining. This was ultimately made up of a lining of chromite inside the brickwork, faced internally with about 2 in. of tar-magnesite mixture. The heating was started as before with wire rope and molten cast iron, and this time with success. As a result several successful casts were made, though with severe trouble in the management of the tap hole, which broke out several times. Ultimately the furnace was cooled down and the tap-hole re-made entirely, but two days after starting the metal again broke out through the inner wall, damaging the transformer more severely than before, necessitating another long stoppage.

While the repairs were in progress, another difficulty was remedied by modifying the shape of the template to give a hearth 7½ in. x 13 in., and so facilitate the feeding of awkwardly shaped pieces of scrap, though doubtless at the cost of a certain loss of electrical efficiency. It may be mentioned that the slag adhering to the walls reduces the free space for feeding, so that the original width of 5 in. sometimes made feeding extremely difficult.

The new lining, except for about 4 in. of chromite underneath, was rammed entirely of magnesite, which, although known to be impure, was the only supply then available.

After starting up as before the furnace worked relatively smoothly for over a week, and if the output was small it was chiefly due to inexperience; as a matter of fact it only averaged about one cast per day. However, the lining cracked and it was emptied to avoid risk of damaging the transformer.

Magnesite Linings

During this time it has been found that nearly pure magnesite was obtainable, the analyses of four samples showing:

Silica (SiO_2)	1.0	1.05	0.45	2.5
Lime (CaO)	0.08	0.20	trace	0.10

A consignment of this was obtained and calcined, but unfortunately it could only be done at the same time and using the same machinery and kilns as for silica bricks. Consequently considerable contamination occurred, and analyses of different consignments used for lining showed silica present from 9.7 per cent to 14.0 per cent. However, subsequent relinings were carried out with this material, at first using tar as a binder, but later employing a mixture of clay and boric acid, recommended by Professor Arnold, of Sheffield University, in the proportion of 140 lb. clay, 20 lb. boric acid and 40 lb. water to 2040 lb. of magnesite; but it was found necessary to largely increase the amount of water.

Decarburization of the Melt

Commencing with the employment of a magnesite lining, improvement was rapid, and early this year operations became nearly normal. Early troubles were largely due to alternate heating and cooling of the lining due to labor trouble and other enforced stoppages mentioned, and as these have been eliminated or lessened the frequency of tapping and consequently the output has increased till for some time between 1900 and 2000 lb. of castings have been regularly obtained every eight hours. Now the period is being reduced to six hours. Apart from the material of the lining, the chief difficulty in the early stages was oxidation of the metal and consequent loss of carbon and manganese content, which besides softening it, made it much less fusible. This was due to the rust on the scrap, to scale formed during preheating, and partly also to admission of air to the furnace by defective covers. When, in the early stages, a heat lasted sometimes 24 hours or more, it is not surprising that on occasion all the carbon was lost and dead soft iron was produced. This has been remedied by more rapid working, and by keeping a little charcoal on top of the metal in the furnace. Indeed, the charcoal is so marked in its effect in facilitating the working of the furnace that it is difficult to make the furnace hands (Cape colored men) use it in sufficient moderation, and for a long time carbon in the steel was nearly always much too high, generally 1.1 per cent to 1.3 per cent. Even now it does not seem advisable to dispense with charcoal entirely, but by exercising proper care, carbon can be kept at about the desired figure, while by stopping the formation of oxide the furnace walls are preserved to a considerable extent from corrosion and their life increased.

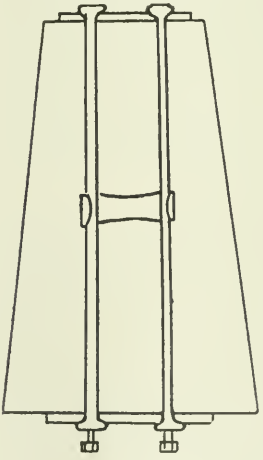


FIG. 3. COVER BRICK

The chief furnace trouble at the present is the formation of a "crust" of solid metal more or less completely covering the surface of the molten metal. It is not serious if noticed and dealt with in time, but if allowed to increase by building up and feeding more metal it entails much labor and risk of damage to the walls in detaching it. It does not seem to be of any

assistance to try and make a slag, which indeed is difficult to keep fluid, but sometimes to clean the metal a little fluorspar has been added. Another difficulty, in a recent lining, arose from trying to incline the trough towards the tap hole. This reduced the cross-section of steel too seriously at the other side, and caused several breakages of circuit after tapping, probably due to the "pinch" effect, so that the tap-hole had to be raised. However, having the hearth level leaves a ring of metal to be removed every time a stationary furnace has to be completely tapped out for relining. In normal operation, lining and working proceed as follows:

Relining

The old lining having been stripped out immediately after it had cooled sufficiently, the bottom is rammed into place with hot rammers, little by little, and then the template supported in position. This is constructed so that when the ramming is completed the sides can collapse to some extent, thus loosening and facilitating withdrawal. (Lately the bottom has been made rather more V-shaped, so as to keep a continuous starting ring with less weight of metal.) The walls are then rammed in the same manner, and when complete, about twelve hours from the last tapping, the template is withdrawn, the walls completed with a course of flat radial brick, the coil of rope inserted and the yoke replaced. This occupies about three hours more. Current is then switched on, and the furnace is ready for more foundry metal within thirty hours of the last cast. Three ladles, about 500 lb. in all, are then carried across from the foundry and poured in. Generally this solidifies, but in two or three hours is molten again and the feeding of scrap commences.

Melting

The scrap has previously been heated to redness in the furnace attached to the drying stove, and is transferred by means of tongs to the electric furnace, feeding in several places through spaces left by removing a cover block. This is kept up for two or three hours more, about 2000 lb. of scrap having been charged, after which the metal is left at rest to become hotter and ready for casting, no metal being ordinarily fed within one hour of tapping. At this stage the required amount of pig iron and manganese steel is added. Towards the end most of the slag is skimmed off on the end of flat iron bars, and shortly afterwards the top tap-hole is opened in the usual manner by drilling out its center, which has been plugged by a friable mixture of magnesite, coal dust and clay (the hole itself being lined with the same mixture as the furnace). When the flow of metal has practically ceased it is stopped by placing two or three suitable flat pieces of scrap against the tap-hole inside the furnace. Any metal in the tap-hole is removed while hot. This removal is important, or a break-away may be caused subsequently, and the hole is then made up again. Thereafter charging goes on as before, but with scrap only, except for the additions at the end. The first two or three heats are cast into dies, since the high carbon, sulphur and phosphorus content from the cast iron would lead to breakage of shanks if cast into shoes; thereafter three shoes and five or six dies, or latterly even eight shoes are made per cast.

Cracks and holes appear in due course in the lining, but so far it has not been found possible to patch them successfully. It is often stated in textbooks that this is done, but inquiries have failed to elicit how.

In order to save time in ramming, a pneumatic hammer tool was used recently, and apparently used too well. Nearly 50 per cent increased weight of magnesite was rammed into the lining, and when this was heated up it expanded and cracked badly. This method is still in course of trial, but with a lighter blow, and seems likely to save considerable time, *e.g.*, the interval between the final cast of the old lining and first cast of the new is reduced to about forty hours only.

Pouring and Casting

A tilting furnace would obviously have prevented much trouble with regard to the tap-hole and tapping, and could doubtless have been made, but in view of the necessity of keeping initial outlay as small as possible the fixed furnace was decided upon. This usually necessitates the intervention of a ladle between the furnace and molds, the metal being tapped into the ladle and poured thence into the molds. Originally, therefore, a ladle and suitable handling gear was installed, the intention being to pour over the lip. However, owing largely perhaps to slow and inexperienced handling in the early stages, a very large proportion of the steel solidified in the ladle, forming skulls which constituted so much waste, it being impossible with the available appliances even to break them up for remelting. In addition, frequent relining entailed much expense and delay. Hand ladles of smaller size were then substituted for a time, three being used in rotation at each cast. This arrangement reduced the loss to some extent, though it was still large, but there was still much lining to be done and, moreover, it was very awkward to operate in the somewhat confined space. Therefore, after some other trials the present method was arrived at.

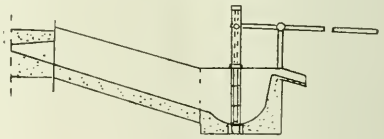


FIG. 4. FORE-HEARTH

As shown in the illustration, Fig. 4, the tapping spout is somewhat lengthened, and has attached to its end a box of sheet steel provided with a bottom outlet through a fireclay nozzle, and forming a kind of forehearth. The spout and forehearth are lined as usual and, of course, patched and faced after every cast. The outlet can be closed by means of a fireclay plug, as usual in bottom teeming steel ladles, this plug being carried on a rod actuated by a lever in front, worked by hand. Directly underneath this, and at right angles to the spout, is a line of rails on which a series of flat cars carries the molds, so that they can be moved in turn underneath the nozzle. This has considerably raised the daily output, and on several days over 3 tons of castings have been produced.

It was soon ascertained that it was much easier and simpler to cast onto iron molds (with sand tops);

moreover, the operation requires less skill. Consequently nearly all the production has been made in this manner. But, while overcoming certain troubles, the use of iron molds introduces others, *e.g.*, when, in the case of shoes, the bottom of the mold, forming the shank of the shoe, is worn and rough, it tends to grip the solidified metal and prevent its normal shrinking, thus leading sometimes to cracking at the butt. In use, this crank rapidly results in breakage. This may be overcome in future by molding the shanks only in sand.

The present arrangement is shown (Fig. 5), and it will be seen that there is very little molding work required. To diminish this still further, trials have been made of tops formed of fire brick and of cast iron, but so far the balance of advantage seems to lie with those

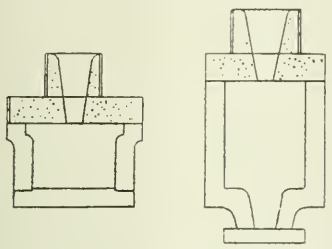


FIG. 5. METAL MOLDS WITH SAND TOPS

of sand. As soon as the mold is filled a little sand is thrown on top and a weight (usually an old shoe) placed on top of that, so that the metal solidifies under a slight pressure. Ultimately the feeder head is knocked off while still hot and the casting is stripped. When cold enough, any fins due to the split molds are trimmed off by hammers, and any irregularity where the head broke off dealt with in the same manner. To obtain sound castings a small amount of aluminium is placed in each mold before casting, this being found more effective than adding it in the furnace.

Temperatures

Attempts were made to ascertain the temperature in the furnace before casting, both by means of a platinum-rhodium thermocouple and Féry radiation pyrometers. Neither method is satisfactory for continuous use; the former is rapidly destroyed and the latter is difficult to use in spite of being mounted directly above the furnace, because the slag chills directly the cover is moved and the metal cools appreciably while slag is being skimmed. The eye, or the old "cutting the rod" test is therefore still depended upon.

In addition to the melting furnace itself, a coal-fired preheating furnace is installed in order to economize electrical power by heating the scrap to redness before it is charged into the electrical furnace, and so arranged that it also heats the drying stove.

The Product

It must be confessed that at first the quality of the product was very irregular, a large proportion being honeycombed with blow-holes, and the carbon content varying widely in different casts. With increasing experience this is being regularized, and a more uniform quality turned out.

Carbon is determined in every cast by the Eggertz color test, a sample for the purpose being dipped out from the furnace on the end of a rod, and at intervals a complete analysis is made. Some of these are given below, and it will be seen that carbon is frequently rather high.

Carbon .	64	1 18	1 12	774	1 07	1 13
Silicon	14	357	149	120	186	20
Manganese	56	600	670	352	52	24
Phosphorus	054	069	043	042		021
Sulphur	043	059	062	057		022
Chromium . .	.20	.14	13	. .		022

Under the circumstances it is scarcely surprising that the percentage of shank breakage among shoes has been somewhat high, but of course the reports so far received from the users mainly relate to the earlier product. Investigation showed that high carbon certainly seemed to predispose to breaking, and why this is so can readily be understood. Excess cementite, although very hard, is also very brittle and apt to break under shock; while if the mass is of eutectoid constitution with about 0.9 per cent carbon, no separate cementite exists, and we have a strong homogeneous material. Even up to 1 per cent carbon the amount of free cementite is scarcely appreciable, and it is therefore endeavored to keep the carbon below that point. If a hydraulic press were available to forge the metal somewhat, it would without doubt be fully equal to the imported. At present, by the use of large headers in casting, it is endeavored to keep the metal as sound as possible, but forging is impossible.

Men Wanted for Engineer Replacement Regiment

THE First Replacement Regiment of Engineers was organized at Washington Barracks, D. C., on December 14, 1917. Its specific purpose is to keep all engineering units of the army at full enlistment strength during the period of this war. This regiment has not only the responsibility of finding men to fill up depleted ranks but it must also fit them to step into the work of trained, efficient and disciplined soldiers.

The men are first given infantry drills which gradually gives way to specific technical training. The engineer soldiers must know how to tie all the important kinds of knots and lashings, to build spar and truss bridges, to construct revetments, dig trenches, place wire entanglements, construct machine-gun emplacements, build pontoon bridges and to construct roads. They must also know the methods of demolition, sapping and mining. Specialized training in lithography, zincography, surveying, mapping, photography, carpentry, blacksmithing, electricity and machinery are also given to those qualified for further training in any of these branches.

Male citizens in the United States who are physically fit, and between the ages of 18 and 21, and 31 and 40, are eligible to join the regiment by voluntary enlistment.

Applicants for enlistment should write to the Commanding Officer, 1st Replacement Regiment Engineers, Room 107, Headquarters Building, Post of Washington Barracks, D. C., for application blank and instructions.

Central Stations and the Manufacture of Electrochemical Products*

By C. A. Winder

TO LOOK at this subject from a central station viewpoint is to consider the economic value of the electrochemist as a customer rather than the engineering questions surrounding the actual use of electric power by him. In the past the central station engineer seems to have taken the attitude along with the apparatus manufacturer that the electrochemist was, strictly speaking, a chemist delving in a field he was perhaps only meagerly acquainted with.

For five years I have been intimately associated with the electrochemists and feel safe in stating that as electrical engineers, especially insofar as their own requirements are concerned, they are as a general rule well qualified; more so in many cases than those with whom they deal. I say this to justify some of the claims they have made which will enter into some of the phases of the situation which I will discuss further on.

But, before considering the economic side of this question, it might be well to look into the power consumption of the various well known electrochemical products, especially those consuming relatively large quantities of power and where the power enters into the chemical reaction rather than furnishing mechanical power. This will determine to a great extent the location of the industry and the price the industry can pay for its power.

This class of electrochemicals will include in the order of their importance, the following: aluminium, ferro-alloys, calcium carbide, artificial abrasives, alkali, chlorine, phosphorus, sodium, carbon disulphide, graphite and similar products. These are all products that are indispensable to the arts and manfactures and at the same time their use has been greatly increased by war demands; demands, by the way, which to a great extent, will not continue after the declaration of peace.

Power Consumption for Various Products

Aluminium consumes the largest amount of power per pound of finished product (approximately 12½ kilowatt hours) and is perhaps more dependent upon the low cost of power than any of the other above mentioned products. Based upon the calculations of electrochemists in a position to know, it seems possible for aluminium manufacture to exist a thousand miles from the center of gravity of its distribution provided power can be obtained at from $20 to $25 a kw.-yr. In this product we have an ideal combination of high consumption of power and low shipping weight.

Next in order considering energy consumption per pound of product is perhaps the artificial abrasives, whose consumption is about half that of aluminium, but the shipping weight of the finished material is quite high. Here we have an industry that cannot stand long freight hauls even with unheard of low prices of power. If the haul of the finished material were two thousand miles, it is doubtful if an artificial abrasive plant could exist where power was free. I do not believe that this industry can stand more than a five hundred mile haul under the prevailing prices of water power.

Calcium carbide, ferro-alloys, sodium, chlorates and phosphorus are in practically the same position as artificial abrasives, all requiring power at the prevailing water-power rates and within close proximity to the center of gravity of their consumption.

Of the ferro-alloys, perhaps ferro-silicon is the most popular just now owing to the high selling price. This price is abnormal, having been brought about by a shortage created by the unprecedented demand for shell steel and armor plate, shell steel requiring some 0.3 per cent silicon, which is a very high percentage compared to the normal run of steel. Furthermore the importation of ferro-silicon from England and Canada has been discontinued and England has even pleaded for some of our ferro-silicon output. Eighty per cent of the ferro-silicon produced in this country comes from the Niagara district, where the power shortage is exceedingly acute and it is practically impossible at the present time to increase this output. Previous to the war, $70 to $75 per ton was considered a fair price for this commodity, it having sold as low as $51, which price incidentally shows no profit whatsoever. Since that time the price has been up above $200 per ton and now is fluctuating between $150 and $175 per ton. This price, of course, is unreasonable, and cannot be expected to remain. Therefore, those who enter into the manufacture of this commodity are treading on rather treacherous ground from an economic standpoint.

From an engineering standpoint, ferro-silicon can be made most economically under normal circumstances in furnaces of about 10,000 horsepower input, and apparently those companies that are now entering this field or contemplate such action are planning on small furnaces. Such engineering cannot withstand the rigors of competition that will follow this war. But, on the other hand, where companies insist on entering this field now to take advantage of the present high prices, limited capital requires the installation of small furnaces.

Another engineering detail in the use of electric power in the manufacture of ferro-silicon has often been overlooked, and it is this particular feature which practically precludes the present day central station from entering this field, though I understand a number of them have been figuring on putting in their off-peak power, particularly their summer valley, into such a load. I am speaking of the question of frequency. As a rule, the central station catering to the lighting load generates at 60 cycles, but 60 cycles almost precludes the operation of a ferro-silicon furnace of any size, the reason being, obviously, that a very poor power factor results from high currents at high frequency. Probably ferro-silicon furnaces of capacities approaching 800 to 1000 horsepower might be built with a result in power factor approaching 90 per cent, relatively larger furnaces would have still lower power factor. This, of course, entails increased cost in the transforming equipment and therefore handicaps you further in the cost of production. Low frequency is a prime requisite to the successful operation of ferro-alloy, calcium carbide and similar furnaces.

United States Government Nitrate plant No. 2 has already encountered a serious difficulty in furnace design for manufacturing carbide, which is a step in the cyanamide process, because of the fact that they have decided on using 60-cycle turbo-generators. How this matter will eventually work out is hard to tell, but ap-

*An address made at the Dayton meeting of the Ohio Electric Light Association. The author represents the General Electric Co. at Niagara Falls.

parently from the engineering done so far, the size of the calcium carbide furnace will have to be materially reduced from the estimated capacity and this, of course, will entail an increased cost of output. Most of the electric furnace products have been developed at Niagara Falls where 25 cycles is the prevailing frequency. Even lower cycles than this are perhaps preferable for electrochemical loads. Consequently the central station at present installed, producing power for domestic and industrial purposes, is handicapped from practically every standpoint.

Impracticability of Off-Peak Power

If we consider off-peak power for such loads as artificial abrasives, ferro-alloys or calcium carbide, we find that an 80 per cent load factor so greatly increases the overhead costs that the power would have to be obtained without any cost at all to be at all attractive. Daily off-peak power for carborundum, for instance, is absolutely out of the question, as a carborundum furnace operates for thirty-six hour periods. Neither can the graphite furnace be considered for the same reason. Here, of course, the operating periods are considerably longer. Valley power covering a period of eight months is an economic possibility that is not attractive to the average electrochemical industry. There are a few electrochemical markets which are seasonable and whose fluctuations correspond fairly well to the valley of the usual public service company. But to produce the average requirements will entail an investment of 50 per cent in excess of the plant operating on a flat load over a year period and would increase the overhead charges to a point where the proposition is not as a rule attractive.

The smallest user of power per ton output is perhaps the caustic and chlorine industry and is consequently the most affected by long freight hauls. We see as a consequence that caustic and chlorine are manufactured near their markets and comprise one of the few electrochemical industries that the central station may hope to attract. But even here we have the unfortunate situation that confronts all electrochemical industries that depend upon power purchased from a public service corporation, that is, a twenty-four hour load undoubtedly penalized from a bookkeeping standpoint in favor of the domestic consumer. This is known to the caustic manufacturers who in the past have obtained power from power companies whose main output is twenty-four hour power and in consequence the steam plant has not been very successful in attracting the load apparently most suitable to this type of service. Apparently this is a matter for the consideration of the rate-making commissions or commissions approving rate-making in the various states. Naturally, such a situation would have to be brought to the attention of the above mentioned commissions by the central stations themselves.

It is true that under prevailing prices of some electrochemicals there may be some central station whose power could be utilized. The shortage particularly in ferro-silicon may be so acute that the Government will commandeer the power in certain large cities just as they have commandeered the complete output of the power companies at Niagara Falls and Buffalo. This necessitates the closing down of non-essential manufacturing plants with the subsequent damages that always accompany such situation, the central station losing not alone its industrial load but also the load of those operatives and employees who, through the fact that they have lost their employment, move from the city. Manufacturing plants (industrial) usually require a large number of operatives per horsepower, whereas an electrochemical industry uses a great many horsepower per operative. Where it is possible these manufacturing industries will move to other communities where power is available.

Readjustment When Peace Comes

When peace comes, as it must in time, be it one year or ten, the electrochemical plants located in cities where the manufacture of their products is uneconomical under normal peace conditions will, of course, fail when competition again becomes keen. It will be those companies located at the present economic positions and possessing water power, which in itself leads to the reduction of costs, whether by virtue of price, quantity or frequency, that will survive this ordeal. The central station may then find itself in the position of having connected load without the ability of their load absorbing its power and it will take a long time to again build up the load to where it was when the war began. Obviously, the only classes of large power users that the modern central station in large cities should solicit are japanning ovens, brass-melting and steel-melting furnaces (where good scrap is available and other conditions correct), as well as hundreds of industrial power-consuming devices now being perfected or which have not as yet become commercially applicable, but will be perfected under the present war stimulus.

It would appear therefore that the various steam-generating companies should use every effort to increase installed capacity of water power for this class of consumer, having in mind the protection of their own interests. Undoubtedly this is true. In the past the steam plant seems to have felt that water power was a competitor of no mean ability, but this is, strictly speaking, not true except in a few minor cases.

In the Niagara district, for instance, the economic situation was vastly improved when the steam plant was installed to take up the daily peaks. We have often been told, but many of us still fail to realize that water power should never be used for loads of short duration. It costs practically no more to generate power for twenty-four hours than for one hour, which is diametrically opposite the steam situation.

Installation Costs of Steam and Water Plants

In the case of the steam plant under normal price conditions, installation costs range around $50 per horsepower with a tendency downward in the future due to new developments in steam-turbine and boiler economics which will be announced to the world after the mad demand for production subsides. On the other hand, an installed horsepower in water-power plants can be safely stated to be about $150 under the same economic conditions. But the future instead of reducing the installation costs as in the case of the steam plant holds nothing for it except increased costs. This is due to the conditions to which water-power rights will be subjected by the present Congress should they eventually realize the necessity of legislation of a nature that will permit of the development of some of the fifty-four million available horsepower in our navigable streams. It is a well known fact that the House of

Representatives in Washington feels that no water-power rights should be granted without monetary consideration to the federal government either in the form of a lease or taxes. Added to this, they have, in all the legislation at present considered, insisted that water-power companies develop the navigable streams with a view of bettering navigation conditions on these particular rivers. This entails heavy expense for locks and headwater improvements which undoubtedly will bring the cost of this class of power to about $200 a horsepower when considered on the basis of prices before the war.

When we consider that we are paying interest on investment for twenty-four hours a day in either steam or water-power developments and our water-power developments cost four times the steam power development, it is easy to see why load factors approaching 100 per cent are essential for water-power plants and that the usual domestic load of four-hour peak tends to the uneconomical use of capital. Considering the steam plant, the major expense is in fuel, which is on a gradually increasing scale owing to the increasing cost of mining coal as well as a slowly but steadily disappearing supply.

When we consider that the year 1917 doubled the installed capacity of steam turbines and that the year 1918, based on orders at hand, will further increase this by 60 per cent of the total installed Jan. 1, 1918, we can readily see what is before us in the way of coal demands which will hardly have a reducing effect on the price of fuel.

Eminent engineers have figured that even with water power at hand, should the load factor be 40 per cent or less, steam power should be used; but should the load factor be 60 per cent and above, water power is the most economical development. The field represented between these two points is subject to local conditions and may or may not be economical water-power or steam-power developments, depending upon other conditions surrounding the particular problem. The only exception to the above would be, of course, a case where the power consumed equalled the total amount of storage available.

Two factors have contributed to the elimination of cheap power; first, the limited development of water power; second, the inability of steam stations to make consistent rates for twenty-four-hour power. This has led to the expatriation of some of our most essential industries. Long ago the only fertilizer industry on this continent, an American company incidentally, went to Canada, where they obtained low power rates. Additions to the Carborundum Company and the Norton Company were built in France and Germany respectively for the same reason. Both of these companies have recently built large plants in Canada. The Union Carbide Company has transferred its carbide production from Niagara Falls, N. Y., to the Canadian side and additions for ferrosilicon in Norway. Lastly, we hear that the Acheson Graphite Company is planning to build at Shawinigan Falls, Que. Thus it is that many of our great industries have gone to other countries in search of cheap power. This may not be serious, but should Canada ever decide to stop exportation of any of these essentials, the United States would find itself in much the same position it was in at the beginning of the war with regard to dyestuffs.

Research Information Committee Formed

THE following statement is authorized by the Council of National Defense:

1. By joint action the Secretaries of War and Navy, with the approval of the Council of National Defense, have authorized and approved the organization, through the National Research Council, of a Research Information Committee in Washington with branch committees in Paris and London, which are intended to work in close co-operation with the officers of the Military and Naval Intelligence, and whose function shall be the securing, classifying and disseminating of scientific, technical and industrial research information, especially relating to war problems, and the interchange of such information between the Allies in Europe and the United States.

The chief functions of the foreign committees thus organized are intended to be as follows:

(a) The development of contact with all important research laboratories or agencies, governmental or private; the compilation of problems and subjects under investigation, and the collection and compilation of the results attained.

(b) The classification, organization and preparation of such information for transmission to the Research Information Committee in Washington.

(c) The maintenance of continuous contact with the work of the offices and military and naval attachés in order that all duplication of work or crossing of effort may be avoided, with the consequent waste of time and energy and the confusion from duplicated effort.

(d) To serve as an immediate auxiliary to the offices of the military and naval attachés in the collection, analysis and compilation of scientific, technical and industrial research information.

(e) To serve as an agency at the immediate service of the commander in chief of the military or naval forces in Europe for the collection and analysis of scientific and technical research information, and as an auxiliary to such direct military and naval agencies as may be in use for the purpose.

(f) To serve as centers of distribution to the American Expeditionary Forces in France and to the American naval forces in European waters of scientific and technical research information, originating in the United States and transmitted through the Research Information Committee in Washington.

(g) To serve as centers of distribution to our allies in Europe of scientific, technical and industrial research information originating in the United States and transmitted through the Research Information Committee in Washington.

(h) The maintenance of the necessary contact between the offices in Paris and London in order that provision may be made for the direct and prompt interchange of scientific and technical information.

(i) To aid research workers or collectors of scientific, technical and industrial information from the United States, when properly accredited from the Research Information Committee in Washington.

The headquarters of the Research Information Committee in Washington is in the offices of the National Research Council, 1023 Sixteenth Street; the branch committees are located at the American Embassies in London and Paris.

The Physical Properties of Copper and the Factors by Which They Are Affected—IV.

By Paul D. Merica
Division of Metallurgy, U. S. Bureau of Standards

(*Concluded from page* 307)

Impurities in Copper; Effect on Physical Properties

OXYGEN

THE constitution of the alloys of copper and oxygen (Cu_2O) shows that oxygen is present in copper as Cu_2O, not dissolved appreciably by the copper (223). There seem to be no published records of test results showing the effect of oxygen on copper free (in the commercial sense) from other impurities. It is, of course, well known that in melting copper it must be brought to pitch in order that it may be cast free from blowholes and possess the best mechanical and "working" properties. If under pitch the presence of blowholes will cause seams in the metal which may open up in drawing; if underpoled the excess oxygen may cause cracking during cold-rolling, and if the oxygen is in amounts as great as the eutectic composition it may also be hot-short.

Hampe (253) found that Cu_2O had no effect on the strength or malleability of pure copper until 0.45 per cent was reached, when a very slight diminution of tenacity was recorded. Ductility in the cold was not affected until 0.9 per cent was reached. Beyond 0.9 per cent the quality of the copper suffered more and more as the proportion of Cu_2O was increased.

Johnson has given some results of tests of oxygen bearing arsenical copper; see Table IX.

The influence of oxygen on copper is chiefly interesting in conjunction with that of other impurities, notably bismuth, antimony, arsenic and lead. It diminishes the embrittling effect of bismuth (Johnson) and lead; this is probably due to two facts: (1) That in the presence of oxygen an oxide of either of these metals is formed which melts at a higher temperature than the metal, and (2) that this oxide is distributed as fine globules instead of thin plates as is the metal.

Greaves (252) has studied the effect of oxygen in copper containing arsenic and antimony, studying the cold-rolling and drawing properties, hardness and microstructure. His conclusions relative to cold-rolling (strips were cold-rolled with annealing from 0.35 to 0.02 in. in thickness) are:

> "As the amount of arsenic increases up to 0.5 per cent the metal may take up more oxygen without suffering deterioration in its capacity for rolling. This quantity of oxygen rises from about 0.05 per cent to 0.2 per cent as the arsenic increases from 0 to 0.2 per cent, then more slowly to about 0.28 per cent as the arsenic rises to 0.5 per cent. . . . When less than 0.3 per cent of O_2 is present, a metal which will roll perfectly is obtained before the arsenic reaches 0.5 per cent.
>
> "In a similar way antimony up to 0.4 per cent reduces the cold-shortness of pure 'dry' copper."

His conclusions relative to wire-drawing tests are that the conditions obtaining are entirely similar to those in rolling copper.

Baucke (Tables IV and X) has some results on the toughness of cast and forged alloys with varying percentages of oxygen.

PHOSPHORUS

The diagram for alloys of copper and phosphorus has been partly established by Heyn and Bauer (224). Phosphorus in the form of Cu_3P is dissolved in copper to the extent of 0.175 per cent. Phosphorus in these small amounts hardens copper, as can be seen from Table VIII of Muenker's (273) results.

SILICON

The alloys of silicon and copper have been studied by Rudolfi (226) and Guertler (227).

Copper with small amounts of silicon (0.02 to 0.10 per cent) is used abroad for telephone wire, electric cables, etc. The electrical conductivity is decreased by about 2 per cent by addition of 0.02 to 0.05 per cent silicon (Guillet).

Apparently in small amounts it does not harden copper appreciably (Vickers 281); the copper cast using silicon as a deoxidizer is often called silicon bronze, although it contains practically no silicon.

SILVER

The constitution of the silver-copper alloys has been studied by Heycock and Neville (228), Lepkowski (230), and others. Copper takes up about 3 per cent of silver in solid solution.

Johnson (261) studied the effect of additions of silver to tough-pitch copper and concludes that up to about 0.2 per cent the tensile strength is increased by about 3 to 5 per cent, the elongation decreased by 10 to 15 per cent, and that "the effect of silver in the proportions ordinarily found . . . is beneficial on the whole as regards mechanical properties and negligible as regards hot-working properties"; see Table IX.

SULPHUR

The constitution of the copper-sulphur alloys has been studied by Heyn and Bauer (231).

The amount of sulphur as Cu_2S taken up by the copper in solid solution is extremely small (< 0.1 per cent).

Opinion seems to be agreed that as little as 0.1 per cent sulphur in copper renders it hot-short (276). No investigation has been made of the effect of sulphur on the mechanical properties at ordinary temperatures.

TIN

The copper-tin equilibrium diagram has been worked out by Heycock and Neville (233), Shepherd and Blough (234), and others. Copper dissolves about 11 per cent of tin, and within these limits it is hardened by the tin addition.

Muenker (273) gives results of mechanical tests on copper-tin alloys; see Table VIII. Baucke finds that tin in small amounts increases the toughness of copper; see Table X. The alloys of tin and copper are called bronzes, and are generally used of compositions from 0 to 25 per cent tin.

TITANIUM

The equilibrium of the alloys of titanium and copper has been studied by Bensel (235) and Rossi (236). Copper dissolves up to 0.32 per cent of titanium. In small proportions this metal raises the tensile strength and lowers the ductility.

TABLE IX—EFFECTS OF BISMUTH, SILVER, AND ALUMINIUM ON THE PROPERTIES OF ARSENICAL "TOUGH-PITCH" COPPER (JOHNSON, 261)

Ingots were made of cathode copper, arsenic and impurity, poled to pitch and cast as 1¼x1¼x6 in. ingots, rolled at bright red heat in S passes to ½-in. rods and quenched.

Some specimens were hammered out flat to ¼ in. thickness cold, then passed through cold rolls set at ¼ in. The specimens were then annealed at dull red heat for ½ hour and quenched in water.

Mark	Chemical Composition			Hot-Rolled Rods				Rods Cold-Rolled and Annealed		Cold Bend Test	Cold Malleability. Reduction in Thickness Under Hammer[1]	Description	Order of hot Malleability[2]
	Oxygen, per Cent	Added Impurity, per Cent	Arsenic, per Cent	Appearance of Ingot	Alternations to Rupture, Arnold Test	Tensile Strength, 1000 Lb./Sq. In.	Elongation in 3 In., per Cent	Tensile Strength, 1000 Lb./Sq. In.	Elongation in 3 In., per Cent				
R	0.089	Nil	Nil	Level	164	33.5	39	.....	....	180° U	89	Slight cracks	1
E	0.066	.....	0.344	Level	190	35.1	41	.....	....	180° U	91	No cracks	2
EE	0.060	.....	0.410	Level	177	35.3	51	32.3	35	180° U	91	Incipient cracks	2
V	0.052	.....	0.361	Level	190	35.3	38	.....	....	180° U	91	No cracks	2
V	0.182	.....	0.300	Elevation	122	32.6	34	.....	....	135° b	67	Incipient split	2
U	0.091	.....	0.383	Depression	152	35.2	47	.....	....	180° U	89	Incipient crack	2
W	0.162	.....	0.427	Depression	160	34.2	45	.....	....	180° U	79	Incipient crack	2
F	0.056	0.042 Ag	0.300	Level	180	35.3	48	32.7	36	180° U	91	No cracks	2
F	0.075	0.087 Ag	0.363	Depression	161	36.0	33	.....	....	180° U	91	No cracks	2
FF	0.063	0.094 Ag	0.417	Level	187	35.6	43	34.0	43	180° U	86	Slight crack	2
G	0.200	0.185 Ag	0.373	Depression	170	36.0	39	.....	....	45° b	81	Incipient crack	2
GG	0.058	0.175 Ag	0.453	Level	174	37.9	39	34.4	46	180° U	90	No cracks	2
H	0.095	0.292 Ag	0.305	Depression	174	36.4	41	.....	....	180° U	88	Incipient crack	3
HH	0.048	0.292 Ag	0.423	Level	180	36.8	47	33.0	37	180° U	83	Incipient crack	3
K 1	0.079	0.052 Bi	0.366	?	186	33.8	50	.....	....	180° U	89	No cracks	5
KK 1	0.055	0.051 Bi	0.420	Level	201	35.2	44	33.8	42	180° U	89	Incipient cracks	5–6
K 2	0.084	0.074 Bi	0.464	Depression	172	35.3	40	.....	....	180° U	85	Incipient cracks	5–6
KK 2	0.068	0.073 Bi	0.403	Level	186	35.4	46	32.7	40	180° U	89	Incipient cracks	6
K 3	0.155	0.094 Bi	0.355	Depression	178	33.8	37	.....	....	180° U	79	Slight crack	5
KK 3	0.084	0.097 Bi	0.390	Level	178	36.0	48	33.1	33	180° U	83	Incipient crack	7
K 4	0.127	0.122 Bi	0.400	Depression	158	35.2	45	.....	....	180° U	87	Slight crack	7
KK 4	0.073	0.124 Bi	0.468	Level	164	36.2	42	33.2	35	180° U	90	No cracks	8
X	0.026	0.014 Al	0.526	Level	199	34.4	44	.....	....	180° U	92	Uncracked	2
Z	Nil	0.320 Al	0.260	Depression	189	35.5	43	.....	....	180° U	79	Deep splits	8

[1]Test piece, 0.75x0.375", placed under hammer and subjected to light blows until cracks appear.

[2]Material falling in classes 1–4 may be rolled at a bright red heat. (The point which determines the classifying of metal between 1 and 4 is the comparative susceptibility to cracking during rolling. Class 5 may be regarded as the critical stage between material fit for rolling at a bright red and material unfit for such treatment, material of this class (5) would better be rolled at a slightly lower temperature. Material in a lower class can be considered unfit for hot rolling.

U = unbroken, b = broken.

ZINC

The zinc-copper equilibrium diagram has been studied by Roberts-Austen (239), Shepherd (240), Tafel (241), and others.

Zinc is dissolved in copper to the extent of about 35 per cent. It hardens copper and first increases, then diminishes its ductility. Curves, Fig. 24, by Webster

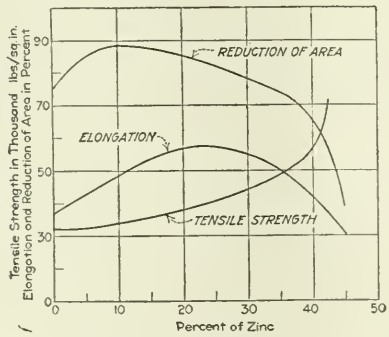


FIG. 24. MECHANICAL PROPERTIES OF ROLLED AND ANNEALED COPPER-ZINC ALLOYS (WEBSTER)

(282) show the mechanical properties of rolled and annealed copper-zinc alloys; i.e., the brasses, made of pure materials.

Baucke finds that zinc in small amounts increases the toughness of copper; see Table X.

GASES IN COPPER

It is generally held that the solubility of gases in solid copper is quite small; in fact, it is to this prop-

TABLE X—BAUCKE (246). EFFECT OF IMPURITIES ON SPECIFIC IMPACT WORK (FRÉMONT TEST) OF COPPER

Specimens 10x10 mm. in section, with 3-mm. saw cut; specimens prepared by casting a 6x6x6 cube and forging hot or cold followed by annealing to 10x10 section. Original electrolytic copper from which samples were prepared analyzed:

Copper, 99.884
Lead, 0.008
Iron, 0.018
Oxygen, 0.080

Composition, per Cent	Preparation of Sample	Specific Impact Work Necessary for Fracture, Kgm.[1]
Electrolytic copper	Forged hot	14.13
Bismuth		
0.025	Forged samples	4 (6 – 2.5)
Arsenic		
0.53	Cold-forged, annealed	14.8 (25 – 5)
0.61	Hot-forged	16.8 (21 –11)
Antimony		
0.37		11.5 (13 – 8)
0.56		4.8 (6 – 3)
Nickel		
0.17	Hot-forged	20.1 (29 –15.5)
0.31	Hot-forged	22.8 (26.5–21)
1.52		28.6 (34 –24)
Tin		
1.20		28.4 (29 –27)
1.92		26.7 (33 –24)
Zinc		
0.68		18.1 (29 –14)
1.42		29.6 (31 –28)
Aluminium		
0.02	(Oxygen-free)	26.0 (27 –24)
0.02	(Cu_2O)	5.2 (9.5– 2)
Manganese		
0.03		30.2 (33 –27)
0.53		30.6 (32 –30)
1.09		34.0 (35 –33)
Oxygen		
0.06		11, 15
0.10		10.8, 12.2
0.12		8.3
0.18		6.0
0.51		9.0

[1]Baucke gives S. I. W. in kilos, but it is assumed that he means kilogram-meters.

erty that the "spewing" upon solidification of overpoled copper is due. The molten copper absorbs gas which is given up upon solidification.

Sieverts (284, 285) has determined the solubilities of H_2 and SO_2 in copper. He finds that 100 grams of copper will absorb the following amounts of gas:

Table XI—Absorption of Gas by Copper

Temperature, Deg. C.	H_2, Solubility in Mg. per 100 Grams	SO_2, Solubility in Mg. per 100 Grams
1400	1.2	
1330		706
1220		596
1120		448
1084 (liquid)	0.6	
1084 (solid)	0.2	
400	0.006	

N_2, CO, and CO_2 are not appreciably soluble in solid copper. He finds that for a constant temperature the solubility is proportional to the square root of the pressure of the gas.

Both silver and gold diminish the solubility of SO_2 in molten copper, the former much more markedly than the latter.

Sieverts (284) concludes that dissolved hydrogen has no appreciable effect on the electrical conductivity up to 870 deg. C., but that SO_2 increases the resistivity (part of this change may have been due to interreaction with the porcelain containing tubes).

"Diseases" of Copper

Copper is, relatively speaking, insensitive to thermal variations in conditions and operations of manufacture. After annealing or after forging operations at a bright red heat (900 deg. C.) it may be slowly cooled or quenched in water, the latter method conferring, according to some, even greater ductility and toughness than the slow cooling.

It is possible, however, to overheat and to burn copper. Heyn (289) has shown that maximum toughness (repeated bend test)is obtained by annealing at 500 deg. C., the time of annealing being without effect. Samples of copper which gave 6¾ 90-deg. bends upon such annealing gave only four when annealed for 90 minutes at 1050 deg. C.

Baucke (287) has shown that heating to 700 deg. C. has practically no effect on the toughness as indicated by the Frémont test; in fact, heating in air or CO_2 at 1055 deg. C. for 15 minutes produced only a slight decrease of the specific impact work necessary to fracture from 77 to 101 ft.-lb. (11.6 to 15.1 kgm.).

Copper should be worked at about 900 deg. C. and not above 1000 deg. C., according to Johnson (290). If heated to and worked at temperatures in the neighborhood of the eutectic melting temperature the copper may be burnt, pits form and grain boundaries become oxidized.

When copper is heated to 800 deg. C. and above in an atmosphere of reducing gases, CO, H, etc., the gases permeate into the copper and reduce the Cu_2O; water is formed, as steam under pressure, and produces fine cracks throughout the copper, which is described as "gassed." Such copper is, of course, weak and brittle. A photomicrograph, Fig. X, shows such cracks near the brazed seam of a failed copper bend steam pipe. The brazing operation was improperly conducted, a reducing flame having been played on the copper with the result that cracks were formed near the surface, leading later to failure. Baucke (287) has reduced the toughness of copper as shown by the Frémont test from a specific impact work necessary to fracture of 94 to 101 ft.-lb. (13 to 14 kgm.) to 14.5 ft.-lb. (2 kgm.) by heating the sample for two hours at 800 deg. C. in hydrogen gas.

Matthews and Thalheimer (191) have carried out the most extensive tests to determine the actual effect of annealing in a reducing atmosphere on the strength and ductility of copper. They used coal gas and annealed for 40 minutes strips of from 0.064 to 0.067 in. in thickness at 600 deg., 800 deg. and 1000 deg. C.

Their average results are given in Table XII.

Table XII—Effect of Annealing in Coal Gas on Mechanical Properties of Copper

Time of annealing, 40 minutes.

	Tensile Strength, Lb./Sq. In.	Reduction of Area, per Cent	Elongation, per Cent
Electrolytic copper	33,000	46	54
600 deg. C.	29,000		22
800 deg. C.	19,000	12	11
1000 deg. C.	21,000	12	11
Mohawk copper	33,000	49	55
600 deg. C.	30,000		27
800 deg. C.	18,000		8
1000 deg. C.	21,000	15–18	16
Copper Range copper	33,000	50	57
600 deg. C.	31,000	39	41
800 deg. C.	21,000	12	11
1000 deg. C.	22,000	16	16

The Copper Range copper, containing 0.296 per cent arsenic, undoubtedly resists the action of reducing gases better than do the purer varieties. This is also shown by experiments by Bengough and Hill (247.)

Corrosion of Copper

Copper is exposed to corrosion by water, air, steam, etc., in a variety of commercial forms, pipe, steam fittings, roofing, etc., so that the question of the corrosion of copper under such conditions is an important one. Practically no systematic investigation has been made, however, of the rate of corrosion of different samples of copper under these various conditions.

Carpenter (296) exposed sheets of aluminium, copper, iron and other metals to corrosion on the roof of an office building, in a railway tunnel, and in smokestack plates, and observed the rate of corrosion expressed in loss of thickness per surface inch per year. His results follow:

Table XIII—Corrosion Loss

	On Office Building, Inches	In Railway Tunnel, Inches	In Smokestack Plates, Inches
Copper (plain)	0.0000	0.004	0.014
Aluminium	0.0011	0.013	
Iron	0.001 to 0.004	0.15	0.018
Steel		0.12	0.020

The copper samples tested were from 99.53 to 99.76 per cent pure. The corrosion was quite uniform in the case of the copper and is seen to be less than that of the other materials.

Corrosion of copper may be quite uniform, a covering and protecting layer of oxide or green basic carbonate or, in marine atmospheres, of oxychloride, being formed. Often, however, the attack is quite local, with formation of pits and furrows. Such pits are mentioned by Corner (297), Merica (299), and others; they are to be attributed to local electrolytic action

caused by the presence near the pit of a substance electronegative to the copper. It is probable that copper oxide and even some of the basic oxidation products of copper may serve as such electronegative "poles."

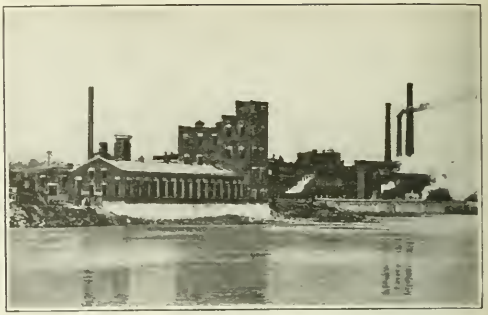
It has been shown by Rhead also (301) that hard copper is more readily corrodible than soft copper, the rate of corrosion of the former having been 0 to 500 per cent greater than that of the latter in his experiments. Eastick (298) also holds that the presence of hard and soft areas in copper are often responsible for local corrosion.

Alcohol from Sulphite-Pulp Waste Liquor

Plant of the West Virginia Pulp & Paper Co. at Mechanicville, N. Y.

By Ellwood Hendrick

"THERE'S a good deal o' miscellaneous eatin' to a sheep," said a Scotchman, and anyone who has ever tasted haggis will confirm the statement. Likewise any chemist who has had to do with sulphite-pulp waste liquor is apt to find a similar disposition within his soul and to declare that there is a good deal of miscellaneous chemistry in it. The liquor contains from 8 per cent to 10 per cent of dry residue, which includes the lignin, with all that the word implies. Less than one and a half per cent of the dry residue is inorganic. In varying quantities there is SO_2 both free and combined, sulphuric acid and about three-quarters of 1 per cent of lime. The sugar content varies from a maximum of 3 per cent to something pretty close to zero as the minimum. One per cent of alcohol from the liquor is a very high yield, even in Sweden. With good practice about two-thirds of the sugar is fermentable.



WEST VIRGINIA PULP AND PAPER MILL, MECHANICVILLE, N. Y.

In 1913 the West Virginia Pulp & Paper Company put up the first plant in the United States at Mechanicville, N. Y., to make ethyl alcohol from this material. Operations began in March, 1914. Counting all the costs, it has not been a profitable undertaking. But where should we be if there were nobody to try things out? The feeble of will are discouraged by unsuccessful experiments, and such men lead only at industrial funerals. The real leaders in industry, on the other hand, have the virtue of perseverance along with the quality of sportsmanship, and often, indeed, they can see romance in a scrap-heap that wrings only tears of gloom from their ungifted fellows.

FIG. 1. ALCOHOL STILL, W. VA. PULP & PAPER CO., MECHANICVILLE, N. Y.

The alcohol plant was built to treat 100,000 gallons of waste liquor a day, which at that time was the regular product of the establishment at Mechanicville. They have been producing 500 gallons of alcohol per day. This is now running somewhat higher owing to changes in methods.

Whether any of the sugar found in the liquor is that which was formed of water and CO_2 by the catalytic action of chlorophyll in the green leaves of the trees while still growing seems still open to question, although it is hardly possible that more than a very small portion of it, if any, can come from this source. Dr. Erik Haegglund, in

an interesting series of articles,[1] claims that wet wood produces more sugar than that which is dry. This has not been confirmed at Mechanicville. He also expresses the opinion that none of the sugar present has its origin in cellulose, although he says that Dr. Eckstrom, under whose patents these works are operated, holds the opposite view. The impression prevails also that a good part of the sugar is the product of lignin; from all of which we may gather that the chemical history of the sugar in sulphite waste liquors is still more or less guessed at.

The presence of fermentable sugars is in part dependent upon the cooking. A high content of free SO tends to increase the sugar in the waste liquor and to shorten the time of the cook. There are also other reasons for the disposition of pulp makers to increase the free SO in their digesters. So we may set down as a rule that if the free SO_2 in the digesters is inadequate, the sugar will be deficient; and we even venture the assertion that the more free SO_2 there is in the digesters, the more sugar will be produced. But we must immediately qualify this statement, because as soon as the SO_2 concentration gets too high, the sugars are decomposed. Indeed, an excess of free SO_2 will destroy the sugar before the cook is completed. Fermentable sugars are more easily decomposed in this manner than the pentoses (xylose). Too high a temperature alone will also destroy the sugar in the digesters. The good feature of the situation is that with the speed of the cook increased by the SO_2 concentration, it is possible so to regulate the process that it is brought to a conclusion at the point where the maximum sugar is obtained. It is not difficult to do this on the one hand, and it is not a rule-of-thumb operation on the other.

From the pulp mill the liquor is run into a great tank. Then the first step in making alcohol from it is to pump it into the neutralizing towers, which have a working capacity of about 40,000 gallons each. This is also a process involving a lot of miscellaneous chemistry. One one-hundredth of 1 per cent of sulphurous acid will kill yeast in 24 hours. Sugar is broken up as soon as a state of alkalinity is reached. Lime in solution is carried over and clogs the still columns and dephlegmator tubes; it takes an interminable time to settle, and fermentation demands a clear liquid. Calcium carbonate produces gypsum, which may leave a clear solution at first, but as it approaches the boiling point a precipitation of extremely small crystals of gypsum takes place. The usual method is to split the troubles by adding the proper quantity of slaked lime at first and half an hour afterwards some pulverized limestone. At Mechanicville lime sludge from the soda pulp mill is employed, which is acknowledged to be the best practice, provided the soda pulp mill is handy.

When the liquor and lime sludge are led into the neutralizing tanks, agitation is accomplished by the introduction of compressed air at the bottom. This is continued for three hours, after which it is allowed to settle for 11 hours; then the clarified liquor is decanted and the sludge, which is now gypsum, is discarded. But the liquor is not yet clear enough, lime and gypsum are still in suspension, and it is still warm. It is therefore run into so-called neutral lye bins which are long and shallow, where it settles for from 10 to 12 hours more. It is now clear enough to go on with the fermentation, but it is not yet cool enough, so from the neutral lye bins it is pumped into a very simple cooling tower. This is constructed with a receiving tank having a perforated bottom at the top of the tower. From the perforated bottom there extend downward for several feet a series of board partitions, several inches apart, which serve as a trickling device. From these the liquor falls down in the form of a very lively rain. Halfway down the drops meet a blast of air from a blower, which blows the liquor pretty well over to one side of the tower, but it is all collected at the bottom in another tank. It is a remarkably effective cooling system.

From the tank at the bottom of the tower the liquor flows by gravity into the fermenting vats. These are

FIG. 2. FERMENTING VATS, W. VA. PULP & PAPER CO., MECHANICVILLE, N. Y.

[1] Published in *Paper*, December, 1917, and January, 1918, Vol. XXI, Nos. 15 to 20.

of concrete, circular in form and hold about 35,000 gallons each. The yeast and its proper food is already in the fermenting vats into which the cooled liquor now enters through three vents, so arranged as to give a circular motion to the entering liquor and thoroughly mixing it with the yeast. By means of this agitation the fermenting begins within about twelve hours. If the liquor is poured into the vat at the top without other agitation, it does not begin to ferment until about 48 hours has elapsed.

The yeast was brought over from Sweden by Dr. Eckstrom, who designed the plant. Dr. Haegglund found types XII and M, distillery yeasts of the Berlin Institute of Fermentation Industry, to be peculiarly suitable.[2] Dr. Drewsen of the West Virginia Pulp & Paper Company made certain researches in the matter and found other yeasts also available. Dr. Eckstrom's yeast, however, is still in use, although, owing to the nature of the liquor and its chemical miscellaneousness, the spent yeast is not reclaimed. To support its growth, spent brewers' yeast is submitted to "autodigestion" by heating it to 40 to 50 deg. C. under pressure. The protein substances are thus digested by the enzyme endotryptose with the consequent formation of amides.

Dr. Haegglund reports that Sweden produces 660,000 gallons of alcohol annually by this method. He also computes that inasmuch as Germany produces 550,000 metric tons of pulp per year, they must be making 5,284,000 gallons of alcohol out of their waste liquors. But statistics based upon what the Germans are probably doing just at this time are not wholly persuasive to us. A computation as to their scraps of paper would carry greater conviction.

We desire to express our sincere obligations to the officers and staff of the West Virginia Pulp & Paper Company, for their courtesy in permitting us to publish the above details of their work and their industrial adventure in this interesting field.

Japan's Electrochemical Industry.—The electrochemical industry of Japan has made enormous strides during the past three years, according to *Denkinotomo*, the Japanese electrical semi-monthly magazine. At the beginning of the war it was one of the minor industries of the country, being grouped with the allied industries. In 1915 it was separately reported, its product being valued at 61,600,000 yen. In 1916 it increased to 117,727,211 yen, while for 1917 indications point to a 300,000,000 yen ($150,000,000) output. The official returns for the past year have not yet been completed.

Splitting Limits in Colorado.—The customary splitting limits as usually agreed upon in ore buying contracts in Colorado are as follows:

Gold	0.02 of an ounce
Silver	0.50 of an ounce
Copper	0.50 per cent
Lead	0.50 per cent
Zinc	1.00 per cent
Iron	1.00 per cent
Insoluble	1.00 per cent
Sulphur	1.00 per cent

[2]Loc. cit.

Simple Washing in the Filter-Press

By D. R. Sperry

TO WASH in a filter-press means to cause a liquid, usually water, to pass through the solids contained in the chambers, displacing from the voids therein some liquid which is not desired in the cake. Washing may also be employed for the purpose of dissolving some solid substance from the cake which may later be recovered from the wash-water. Instead of water, other liquids may be used with which to displace the liquid in the cake or to dissolve some portion of the solids in the cake. Thus it can be seen that washing, lixiviation or extraction may be carried on in the filter-press without removing the solids from the chambers. Indeed the above functions may be performed upon the solids in a filter-press by merely operating the proper valves. If desired, the wash-water can enter the filter-press by a separate channel and leave by a separate channel, so that the connections for the wash-water entrance and for the wash-water exit may be made permanent.

Kinds of Washing

There are two separate and distinct kinds of washing employed in the filter-press, namely, simple washing and thorough washing. The first is not necessarily less

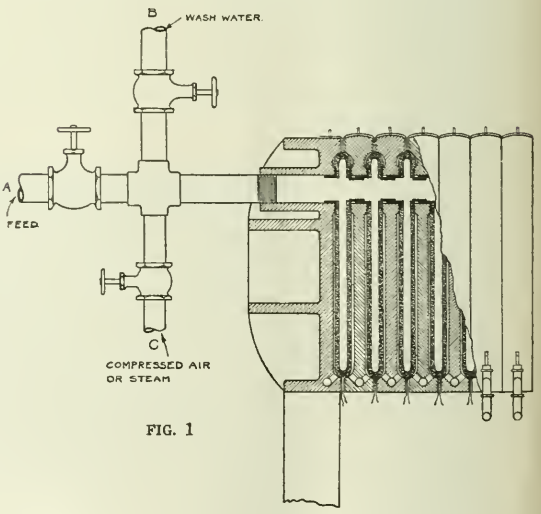


FIG. 1

thorough than the second, but it is much simpler in operation and can be used only in special cases to advantage. This kind of washing is used in the so-called self-dumping filters only because it is impossible to use thorough washing in that kind of filter. Selection of which of the two types of washing should be used in the filter-press depends upon the character of solids in the substance to be filtered and upon its chemical nature as regards acidity or alkalinity. The kind of filter-base used may also be a controlling factor as to whether simple or thorough washing is the most suitable to use.

Simple Washing

In simple washing the filling of the chambers of a filter-press must stop before the solids forming on

the filter-base have met each other. In other words, filling of the filter-press must stop while there is still an unfilled space down the center of the chamber. A filter-press which has reached this point of filling is shown in cross-section in Fig. 1. When this stage is reached the material which is being fed into the filter-press is closed off, as would be done if valve *A* were closed, and valve *B* running to wash-water supply opened. The pressure of the wash-water should be equal to or greater than that used in filling the filter-press. Under these conditions the wash-water soon displaces the mixture remaining in the unfilled space and itself passes through the deposited solids, against the plate surface and out through the cocks the same as the filtrate did during the filling process. The washing process is allowed to continue until the issuing wash-water indicates by its physical or chemical characteristics that the desired effect upon the solids has been reached. The wash-water is then closed off, and frequently compressed air is admitted into the filter-press as would be done by closing valve *B* and opening valve *C*. The effect of the air is to displace the wash-water remaining in the center of the cake as well as a certain amount of that held by the cake itself. In other cases steam instead of air may be admitted through valve *C*, this having the effect of displacing the wash-water and also of drying the cake to a certain extent.

Simple Washing with Separate Connections

In the case of simple washing just described it will be noted that no change whatever in the internal arrangement of the filter-press was necessary, the wash-water, air, or steam entering the chambers along the same path used by the material to be filtered. The wash-water thus issues from the filter-press cocks and into the gutter. It frequently happens that it is not

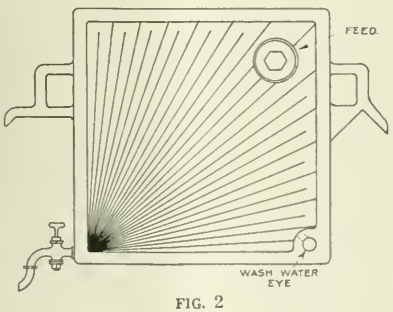


FIG. 2

desirable to have the wash-water or solvent leave the filter-press via the cocks and gutter. In that case a separate outlet for the wash may be arranged.

This is brought about by placing an eye usually in the lower corner of the plate opposite the cock. This eye has a port which connects it with the surface of the plate. A plate of the recessed type having a separate outlet for wash is shown in Fig. 2. When plates with a wash-outlet eye as shown are placed in a filter-press, the wash eyes register with each other, forming a continuous channel from one end of the filter-press to the other, one end of the channel being formed by the movable head, the other by an inlet placed on the fixed head. Due to the ports which connect the eyes with the plate surfaces, the wash channel connects, as it were, all of the plate surfaces in parallel. The wash channel is of course separate and distinct from the feed channel.

In Fig. 3 a cross-section is shown through a filter-press arranged for simple washing with separate outlet for wash. Two sections are shown, the upper one is taken through the feed-inlet and the cock-outlet, while the lower one passes through the center of the plate and the wash-outlet channel. A study of the upper

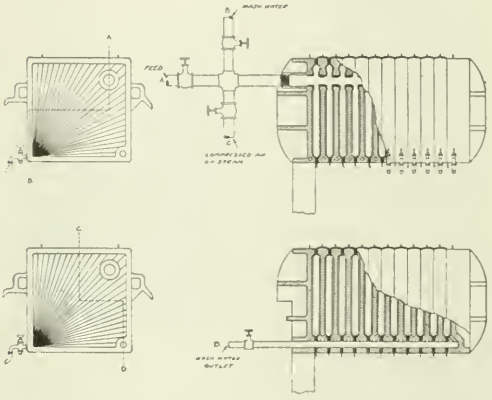


FIG. 3

cross-section shows that the material fed into the filter-press through the inlet located in the fixed head traverses the entire length of the filter-press by means of the openings through the grommets, thus filling all of the chambers formed by the recesses in the plates. During the feeding operation the valves *B*, *C* and *D* are closed while *A*, of course, is open. The material to be filtered is pumped or otherwise forced into the filter-press. As the chambers formed by the recesses in the plates are bounded by canvas or some other filter-base, the solids are caught on it while the liquid passes through filter-base and deposited solids, issuing from the back side of the filter-base and against the surface of the plates. The liquid reaching the surface of the plate is conveyed by means of grooves directly to a lower corner of the plate and out of the filter-press by way of a cock placed at the corner to which the grooves lead.

The filling process, as the depositing of the solids is called, is allowed to continue until a layer of solids is formed on the sides of the chamber of such a thickness that the chamber is not filled solid but an open space left in the center of the chamber. In other words, the solids on opposite sides of the chamber are not allowed to build up until they touch each other, but the process is stopped while there is yet a space between them. At this point it is well to note that if thorough washing, instead of simple washing, were to be employed, the chambers would be allowed to completely fill, instead of only partly fill as in the case considered. When filling has progressed to the proper point, valve *A* is closed, valve *D* opened, valve *B* opened and all of the cocks closed. When this is done the wash-water flows to all the open spaces purposely left down the center of each chamber, following the same route as that previously

taken by the material to be filtered. The wash-water soon displaces the material to be filtered which occupied the open places in the chambers, and itself passes through the deposited solids. As it issues on the back side of the filter-base it flows down the grooves on the plate surface, and, since the cocks are all closed, must flow into the wash channel formed by the eyes in the lower corner of the plate, as shown in cross-section in the lower part of Fig. 3. The pipe connected to the filter-press head at *D* conveys the issuing wash-water to any desired point.

The washing process is allowed to continue until the desired substance has been dissolved or displaced from the solids through which it flows. Chemical or physical tests of the issuing wash-water indicates when the process has continued long enough. When washing is finished valve *B* is closed and the filter-press may be opened ready for another cycle. If, however, it is desired to displace a large portion of the wash-water, valve *C* is opened, thus admitting compressed air or steam. This is allowed to continue until very little wash-water issues from the filter-press, at which point valve *C* is closed. It should be noted that if desired valve *D* may be closed and the cocks opened in order to allow the air or steam to discharge into the gutter.

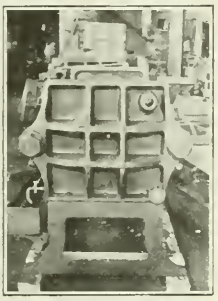


FIG. 4

In Fig. 4 a view is shown of a filter-press arranged for simple washing with separate outlet for wash. The inlet is shown in the upper corner, while the outlet for wash-water can be seen in one of the lower corners. The connections for feed, wash-water, air or steam, and wash-outlet can be seen. The cocks and gutter which carry off the filtrate can be observed along one side of the apparatus.

It can readily be understood that if desired, frames can be placed between the recessed plates, forming a wider chamber. In the lower corner of the frame, corresponding to that in which the wash-water outlet-eye is placed on the plates, an eye must be placed in order to preserve the continuity of the wash-water outlet channel. In Fig. 5 is shown a few plates in cross-section having frames between them. Two cross-sections are given; one, the upper, through the feed-inlet and cock-outlet, the other, the lower, through the center of the plate and the wash-water outlet channel. A picture of the frame is shown in Fig. 6.

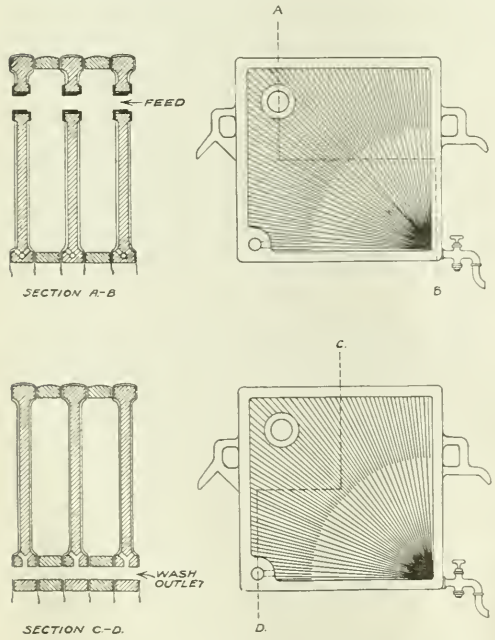


FIG. 5

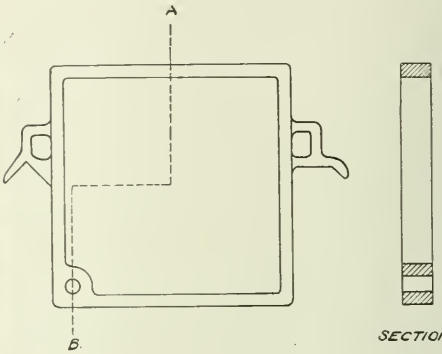


FIG. 6

New Officers of the Engineering Council

At the first annual meeting of the Engineering Council, on Feb. 21, J. Parke Channing was elected chairman, Harold W. Buck first vice-chairman, George F. Swain second vice-chairman and Alfred D. Flinn secretary. The following committees were appointed:

Executive committee: The Chairman, the two vice-chairmen, and David S. Jacobus, Calvert Townley, George J. Foran.

Finance committee: E. Wilbur Rice, Jr., chairman; Charles F. Loweth, Sidney J. Jennings, David S. Jacobus.

Rules committee: J. Parke Channing, chairman; Clemens Herschel, Nathaniel A. Carle, Irving E. Moultrop.

Public affairs committee: Charles Whiting Baker, chairman; George F. Swan, Benjamin B. Thayer, E. W. Rice, Jr., Charles E. Skinner.

American engineering service: George J. Foran, chairman; George C. Stone, Alfred D. Flinn, Dr. Addams S. McAllister, Edward B. Sturgis, secretary.

War committee of technical societies: D. W. Brunton, chairman; Arthur H. Storrs, secretary; James M. Boyle, Nelson P. Lewis (American Society of Civil Engineers), Edmund B. Kirby (American Institute of Mining Engineers), A. A. Greene, Jr., R. N. Inglis (American Society of Mechanical Engineers), Harold W. Buck, Dr. Addams S. McAllister (American Institute of Electrical Engineers), Dana D. Barnum, E. C. Uhlig (American Gas Institute), Joseph Bijur, Dr. Charles A. Doremus (American Electrochemical Society), Louis B. Marks, Preston S. Millar (Illuminating Engineering Society), Christopher R. Corning, George C. Stone (Mining and Metallurgical Society of America), Henry Torrance, F. E. Matthews (American Society of Refrigerating Engineers).

Report of Smelter and Ore-Sales Investigation Committee, State of Colorado, 1917

IN RESPONSE to a popular demand which has been rather insistent in some parts of Colorado for several years, the General Assembly in 1917 authorized the appointment of a Smelter and Ore Sales Investigation Committee to inquire into the buying, selling and treatment of ores and concentrates in Colorado, and to make such recommendations regarding charges or schedules as might be appropriate. The committee comprised two members of the State Senate and three of the House of Representatives, and the sum of $15,000 was appropriated for their use. Mr. O. R. Whitaker, a consulting engineer of Denver, was employed by the committee to make a technical investigation and report.

Hearings were held in Georgetown, Idaho Springs and Central City, where a number of witnesses appeared. The testimony was, for the most part, a repetition of the same statements, and the hearings were discontinued.

Typical Testimony at Hearings

Mr. A. E. Simpson of Georgetown presented testimony which is typical of the attitude of the small ore-producer. He found no objection with sampling methods nor with the accuracy of the financial returns. His main objection was that the schedules are designed to mystify the ordinary miner, are quite arbitrary in their provisions, and do not return to the producer fair proportion of the metal value of the ores. The latter objection, *i.e.*, that the schedules are not high enough, has lost some of its force because new schedules were issued about the time the investigation started, wherein the miner is paid 75 per cent of the market increase, over the base rate for lead, rather than 50 per cent as formerly. Mr. Simpson was of the opinion that, although returns in recent years were greater due to increased market value of metals, they were not in proportion to the increased cost of ore production.

Mr. Fred S. Caldwell, general manager for the C. H. W. Mining Co., of Central City, stated the manager's position. He said that the committee was charged with determining the answers to the following questions:

(1) What does it cost to smelt the different ores of the various mining districts of Colorado?

(2) What are the actual losses on the different metals during the smelting of their ores?

(3) What is the actual cost of refining base lead bullion and copper matte containing gold and silver?

(4) What are the losses on metal content in the refining of base lead bullion and copper matte containing gold and silver?

Mr. Caldwell exhibited settlement sheets on 41 lots of ore shipped during 1916, which have been summarized in Table I.

In explanation of this table, "Metal Content Less Deductions for Loss in Smelting" represents the sum of the dry weights multiplied by the assay. The analysis of the lead and copper is reduced by 1½ per cent (1 per cent since Sept. 1, 1916, according to the new schedule), which deduction is explained by the ore purchaser as covering the loss in smelting. It is supposed that it requires 90 days to smelt, refine and market the metal; consequently the second column represents the value of the metal 90 days after it was accepted by the smelter. "Returns to Miner" represents the amount paid by the smelter less the treatment charges and freight. The "Gross Margin," therefore, represents the gross profit accruing on these shipments. The unit "Refinery Charges" were taken from *Technical Paper* 83, Bureau of Mines, by C. H. Fulton, and the gold and silver purification estimated at 0.09 cents per pound of lead. "Net Margin" represents the smelters' profit above the profit on the treatment charge, and the refiners' outfit, *i.e.*, an investment of $43,446.33 pays $7,069.63 in 90 days, which is at the rate of 65 per cent per anum.

Table I.—Summary of 41 Lots Shipped by the C. H. W. Mining Co.

Metal Content Less Deductions for Loss in Smelting	Market Value 90 Days from Sale		Returns to Miner		Gross Margin	Refinery Charges Plus Freight on Metal		Net Margin
	Total	Average	Total	Average		Rate	Am't	
Au 1,386.14 oz.	$28,651 36	$20 67	$27,002 33	$19 48	$1649 03	.....	$151 37	$1846 94
Ag 9,791.28 oz.	7,070 18	$0 722	6,720.90	0 686	349 28	..		
Pb 168,181.5 lb.	12,744.34	7.58c	6,432.19	3 82c	6312.15	1.01c lb	1698 63	4613 52
Cu 14,163.8 lb.	4,126.70	29 13c	3,290 91	23 23c	835.79	1.6c lb.	226.62	609 17
Total ..	$52,592 58		$43,446 33		$9146 25		$2076 62	$7069 63

Mr. Caldwell submitted that if this analysis is not correct, and the indicated profit is too high, it is because (a) the treatment charge assessed by the smelter is too low, (b) the deductions for metal loss in smelting are too small, (c) the refining cost is too low, or (d) there exist large refining losses which are not included. He also expressed the opinion that the producer should have the option of receiving metal in return for his ore, after paying a proper treatment charge; this would avoid the necessity of heavy charges assessed by the smelters supposedly to protect themselves against violent market fluctuations.

Mr. Robert H. Sayre, mining engineer of Central City, presented the views of the Gilpin County Mining Association. He compared contracts offered by the U. S. Smelting Co. in Utah with the schedules of the American Smelting & Refining Co. in Colorado, in which the former appeared much more reasonable. For instance, the Utah smelter pays for gold if above 0.02 ounce, against 0.05 ounce in Colorado. Copper deduction for smelting losses is 0.6 per cent in Utah and 1.5 per cent in Colorado, while the price deduction is 2½ cents below quotation, against 6 cents.

Report of Committee's Engineer

The results of the technical investigation made by Mr. O. R. Whitaker are given in the form of typical

schedules, together with an analysis of the cost of ore treatment in Colorado. His report covers operations during a period of five years from January, 1912, to December, 1916, inclusive, and deals with ores containing gold, silver, copper, lead and zinc in commercial quantities. In figuring plant depreciation, he assumed that the life of the plant is 10 years, and a charge of 10 per cent on plant valuation is made to cover this item. Interest charges are figured at 5 per cent per annum. Average annual metal prices are used in computing metal values for the period under review. A summary is given in Table II.

Ore Buying and Selling

The buying and selling of ores and metallurgical products, like any other industry, has but one object in view, that is to show a profit on the business done. It is a commercial transaction in which each party uses the knowledge he has in the protection of his interests.

The mills and smelters have always a clear knowledge of the results of their operations, such as cost of production, treatment, recovery, losses and the price of the product, from which they figure how much will be made on each ore purchase. The producers and sellers of the ores are possibly not so familiar with the details of the treatment processes used, therefore a clear explanation of the contract would be of great assistance to them.

Table II—Summary of Operation of Colorado Ore-Treatment Plants

	Colorado Ores Treated in Custom Mills 1912-1916, Incl.	Colorado Ores Treated in Concentrating and Separating Plants, 1912-1916 Incl.	Colorado Ores Smelted to Colorado Zinc Plants, 1912-1916 Incl.	Colorado Ores Smelted to Colorado Lead Smelters, 1912-1916 Incl.	Outside Ores Smelted to Colorado Lead Smelters, 1912-1916 Incl.	Total Ores Smelted in Colorado Lead Smelters, 1912-1916
Ore treated, tons	2,508,933	1,025,000	79,755	3,140,018	734,688	3,874,706
Value of ore stock			$215,000	.....	.....	$1,695,400
Value of product in transit	$750,000	$550,000	125,000	.....	.....	2,300,000
Time in process, days	30	45	45	.....	.....	60
Value of plant	$1,850,000	$1,150,000	$500,000	.....	.....	$2,700,000
Credits						
Gross metal value	$19.06	$35.11	$74.11	$26.86	.....	.....
Paid shipper and freight	13.81	16.98	28.77	17.95	.....	.....
Margin for treatment	$5.25	$18.13	$45.34	$8.91		
Debits						
Cost of treatment	$2.00	$3.00	$21.47(a)	.....	.....	$4.35
Metal losses	1.14	10.83	13.95	.....	.....	1.34
Refining and marketing	0.25	2.10	1.17	.....	.....	1.66
Total	$3.39	$15.63	$36.59	$7.35		$7.35
Operating profit	$1.86	$2.50	$8.75	$1.56	.....	.....
Taxes, depreciation (10%) and interest (5%)	0.40	0.40	1.50	0.61		
Average net profit per ton	$1.46	$2.10	$7.25	$0.95		
Per cent of gross value	7.6%	6.0%	9.7%	3.5%		
Analysis:—						
Au (oz.)	0.92	0.02	0.22	0.526	0.684	0.439
Ag (oz.)	0.08	2.50	6.6	12.34	44.95	18.53
Cu	.....	Trace	.....	0.61	0.52	0.64
Pb	.....	5.5	4.0	6.76	32.65	11.67
Zn	.....	16.0	35.5	.....	.....	.....

(a) Includes $1.94 for residue treatment.

Since the reduction plants, such as mills and smelters, are built solely for the business of ore treatment, the expense of their operation must necessarily come from the realization of the metal values extracted from the ores treated. It is necessary, therefore, for the companies when purchasing ores to charge the producers with the total cost of treatment, metal losses, refining, marketing, depreciation and interest in addition to their own profits. In determining the ultimate profits on the business, the time between the settlement for the ores to the producer and the realization on the product is very important. Where large stocks of ores are carried at the plant and the amount of refined or semi-refined product in transit is large, sudden variations in the market price of the metals have a decided effect on the increase or decrease of the profits.

In times of high metal prices, ore production is stimulated and stocks are consequently increased. With a low metal market the reverse is true. Also, except under abnormal conditions, the market declines more rapidly than it rises. Therefore, unless some provision is made for the protection of the purchaser of ores carrying metals which fluctuate in price, a loss is more likely to occur than a gain.

Ores are purchased in the open market as offered at the terms agreed upon, and usually without obligation on the part of the producer as to quantity. Time contracts are often made with producers when special ingredients are supplied or a definite tonnage of ore assured.

With a treatment plant operating in, or tributary to a substantial ore supply, it would be impossible to settle for and treat the ores from the various mines immediately on the date of receiving them. Therefore it is necessary to settle on some agreed basis.

No metallurgical process recovers all the metal values from the ores. Therefore the payment for the full metal content at market prices cannot be expected. Deductions are made for treatment, losses, marketing, etc., and paying bonuses where required, making necessary some form of ore selling contract.

The existing ore schedules are the result of a gradual evolution of the ore purchasing business, and in some form or other take into account, by direct treatment, charges or metal deductions, the items of principal importance to the purchaser. Inasmuch as these schedules are drawn to cover, in one contract, the business of paying for the values in the ore, the treatment, the losses in the treatment, the refining and selling of the recovered products, the bonuses and penalties and a protection to the purchaser from loss due to sudden market fluctuations, they are complex. In their use for calculating the value of an ore to a plant, a system of discounts and charges is necessary.

Typical Mill and Smelter Schedules

Custom Cyanide Mill Schedules

The following is a representative schedule for Cripple Creek gold ores treated in custom mills and smelters, prices f.o.b. district, gold at $20.00 per ounce:

Custom Concentrating Mill Schedule

Value up to	$10.00 per ton,	$4.00 per ton freight and treatment
From $10.00 to	$15.00 per ton,	5.00 per ton freight and treatment
From 15.00 to	20.00 per ton,	6.00 per ton freight and treatment
From 20.00 to	25.00 per ton,	6.25 per ton freight and treatment
From 25.00 to	30.00 per ton,	6.50 per ton freight and treatment
From 30.00 to	40.00 per ton,	7.00 per ton freight and treatment
Over	40.00 per ton,	8.00 per ton freight and treatment

Schedules for the purchase of ores to be treated in concentrating and separating plants are complex in that they are used to calculate the price to be paid for ores containing several metals. These schedules usually start with a *base price*, for ores of a certain metal con-

tent at a fixed market price and stated delivery. Unit variations are added or deducted according to the grade of the ore and market variations are also allowed and figured on the market price of the metals affected and are calculated from a stated quotation given in the contract. The gold and silver are usually paid for at a certain price per ounce within specified limits.

There is usually no direct treatment charge made in the purchase of these ores. The cost of treatment, metal losses, etc., together with the profit, is made up from deductions from the various metals contained.

A representative schedule on a zinc-lead-iron sulphide ore is as follows:

Base price per ton, f.o.b. Denver, $6.15

Normal analysis: Zn 25 per cent
Ag 5 oz.
Pb (wet) 5 per cent
Insoluble 7%

Normal metal price, Zinc 5.5c. per lb. St. Louis quotation
Lead 5.5c. per lb. New York quotation

Unit variations:

Penalty for insoluble: 5c. for each per cent above 7.

Zinc: ± 43c. for each per cent above or below 25 per cent

Lead: ± 40c. for each per cent above or below 5 per cent

Silver: ± 30c. for each ounce above or below 5 per cent

Market variation:

Zinc: 7c. per unit (20 lb.) for each $1.00 change in spelter quotation from $5.50 to $7.00. 3½c. per unit from $7.00 to $13.00 maximum.

Lead: 7c. per unit for each $1.00 change in lead quotation from $4.50 to $11.00 maximum.

Gold: $8.00 per oz. from 0.04 oz. to 0.10 oz.
10.00 per oz. from 0.11 oz. to 0.20 oz.
12.00 per oz. from 0.21 oz. to 0.30 oz.
14.00 per oz. over 0.30 oz.

ZINC SMELTER SCHEDULE

Schedules for the purchase of zinc ores are made up from a base price, at a given market for ores of a specified grade. Unit and market variations are according to grade and metal quotations. The deductions made provide for the treatment, metal losses and profit to the smelter. For the operations of the Colorado zinc plants ores containing gold and silver are preferable, and a schedule similar to that used by the concentrating plants would be more preferable than the following:

Representative Schedules for Zinc Ores

F.o.b. Missouri river points. Based on 5c spelter market.

Oxidized		Sulphides
25 to 45	Metal content, % Zn.	38 to 50
25%	Minimum metal content, % Zn.	38%
$21.00 for 40% Zn	Base price, per ton of ore.	$26.95 for 50% Zn
$1.00	Unit variation, up or down.	$1.00
	Market variation:—	
60% of value	Market from $5.00 to $6.00 per 100 lbs.	75% of value
+50% of value	Market from $6.00 to $15.00 per 100 lbs.	+50% of value
+40% of value	Market above $15.00 per 100 lbs.	+50% of value

COPPER-LEAD SMELTER SCHEDULE

Schedules for the purchase of copper-lead ore are usually complex. In order to cover its expense, the smelter usually pays for a percentage of the actual contents of the ore at a price below the market quotation.

For gold in ores, no payment is made for gold of 0.03 oz. or lower, and in some cases if less than 0.05 oz. is present. Also, a price of $19.00 to $19.50 per ounce is paid for the gold, as compared to the actual value of $20.67, which two deductions are intended to cover losses in smelting, marketing, etc.

Ninety-five per cent of the silver content in ores is usually made; likewise no payment is made if the content is less than 1 or 2 oz. per ton.

For copper, a deduction of from 1.0 to 1.5 per cent is made at the quotation, less 3 to 6 cents per pound, depending upon the grade of the ore. Furnace practice in treating copper ores in lead smelters shows an average loss of 5 to 6 lb. of copper per ton of ore treated. The customary deduction of 1.5 units for loss is an arbitrary one and is governed by the quantity of copper ores received by the smelter during a definite period. Since copper is not contained in all ores received by the lead smelters, slag absorption will cause loss continuously, which must be provided for.

Payment for the lead in ores may be made by deducting from 1.0 to 2.0 per cent for the wet analysis to arrive at the so-called "dry-assay," and the balance computed from the current quotation, which is generally figured from the New York sales price of the American Smelting & Refining Company on the date of settlement. In case this sales price, or "quotation," is $4.00 per 100 lb. or less, the seller of the ore received 90 per cent of the quotation for the lead in his ore shown by the dry assay. Should the quotation be over $4.00 per 100 lb., the seller of the ore also receives one-half (or three-quarters in some instances) of the excess. The excess deduction is designed to be a protection for the purchaser against sudden market fluctuations.

In case the settlement is made under the "Unit and Quotation" system, a base price per unit (B) is given in the schedule which varies with the lead-content of the ore. This base is on the supposition that the quotation for lead is $4.00 per 100 lb., and for Clear Creek, Gilpin and Boulder districts is as shown in Table III.

TABLE III

Dry Lead, Per Cent	Base Price per Unit, Cents
5 to 10 incl.	40
Over 10 to 15	43
Over 15 to 20	45
Over 20 to 25	47
Over 25 to 30	49
Over 30 to 35	51
Over 35 to 40	52
Over 40 to 45	52
Over 45 to 50	53
Over 50 to 55	54
Over 55	55

In case the quotation (Q) is more than $4.00, the price paid per unit is figured from the following formula:

$$\text{Price} = B + \frac{\$3.60 + \frac{1}{2}(Q - \$4.00) - \$4.00}{5}$$

In case the quotation (Q) is less than $4.00, the price is figured as

$$\text{Price} = B - \frac{\$4.00 - (Q \times 90 \text{ per cent})}{5}$$

From a large number of schedules given in Mr. Whitaker's report, those in Table IV are representative.

The non-payment for the metals below a certain limit is intended to cover losses and give a commercial protection to the smelters. When these ores are smelted with ores carrying enough of the metals to take care of their proportion of the slag absorption and other losses, then all the excess above this is recovered.

In ores containing under 5% per cent lead, the lead is sometimes paid for as iron at 15c. per unit, but usually nothing is paid. In smelting this ore together with sufficient high-grade ore to bring the lead on the charge high enough for furnace requirements, all of the lead in excess of 30 lb. per ton would be recovered, according to general practice. The commercial reason for this deduction is that the lead content is below smelting requirements, and this ore can only be treated to advantage along with a higher grade lead ore. The limited supply of high grade lead ores therefore controls the smelting capacity on low-grade lead ores. These low-grade ores are not profitable to the smelter for their lead content when considered by themselves, as they can only be smelted by recharging bullion into the furnace, to bring up the lead on the charge, thereby increasing losses and costs.

TABLE IV—SCHEDULES OF ORES AND CONCENTRATES TO LEAD-COPPER SMELTERS, FROM CLEAR CREEK, GILPIN & BOULDER DISTRICTS, COLORADO

Rates f.o.b. cars Denver. Minimum shipment, 1 car-load.

	General Schedule, All Classes Ores and Concentrates	Dry Concentrates	Special Schedule, Lead Ores and Concentrates	Lead Concentrates
Gold, per oz., 0.05 oz. to 2.00 oz	$19 00	$19.00	$19 50	$19 00
Gold, per oz., 2.00 oz. and over	19 50	19 50	19 50	
Silver, if 2 oz. or over	95% N. Y. quotation	95% N. Y. quotation	95% N. Y. quotation	95% N. Y. quotation
Dry copper = wet assay less 1.5%:				
Up to 5%	Casting copper −6c	Casting copper −6c	Casting copper −6c	
5% to 10%	Casting copper −5c	Casting copper −5c		
10% or more	Casting copper −4c	Casting copper −4c		
Silica insoluble:				
Limit	..	10%		10%
Penalty per unit		10c		10c
Zinc:				
Limit	10%	5%	10%	10%
Penalty per unit	50c	30c	50c	50c
Dry lead = wet assay less 1.5%:				
Up to 5%	None			
5% or more	25c unit			
Base prices per unit			See table above	See table above

Treatment Charges	Gross Value	Charge	Gross Value	Charge		
	Up to $14	$5 00	Up to $35	$3 50	See Figure 3	Figure 3
	$14 to $20	6 00	$36 to $80	4 00		
	20 to 25	6 50	Over $80	4 50		
	25 to 30	7 00				
	30 to 35	7 50				
	35 to 40	8 00				
	40 to 45	8 50				
	45 to 50	9 00				
	Over $50	10				

The average lead content of the Colorado ores smelted from 1912 to 1916 was 6.76 per cent. Since this is below the requirements for economic lead smelting, the deficit therefore must be made up by the purchase of high-grade ore from outside the state.

General Remarks on Smelting

ZINC SMELTERS

The main requisites for a zinc smelter are cheap ore and cheap fuel. Where by-products are made, marketing facilities are also important. The Eastern zinc smelters are in the natural gas fields furnishing cheap fuel. The Missouri and Oklahoma ores are higher in grade and cheaper to produce than the Colorado ores and are more desirable for a zinc smelter. Owing to the increased cost of operation in Colorado, only crude ores of special composition are available, mainly impure complex zinc ores carrying gold and silver values.

The losses in zinc smelting are high and fuel consumption is heavy. The usual practice figures a loss of 8 units of metallic content and from 2½ to 3 tons of fuel per ton of ore smelted. Losses in percentage would vary from 12½ per cent on a 64 per cent zinc ore to 25 per cent on a 32 per cent ore. These losses are due to absorption by retorts (which is not recoverable), impurities, burning of zinc, and the formation of non-recoverable compounds. The deduction for freight would depend upon the location of the plant. Treatment charges will vary $16.00 to $22.00 per ton of ore.

LEAD SMELTERS

Low-grade ores are frequently produced in the prospecting for high-grade ores and also incidentally to the production of the latter. A sliding scale of treatment and purchase of these low-grade ores is justifiable in order to stimulate production. The loss to the smelter in smelting the low-grade ores must be borne by the high-grade ore in order to bring the average to a reasonably profitable basis. Should this not be done, the operations would be on a smaller scale, with proportionately increased costs for both.

In order to successfully operate a smelter the mixtures going to the furnaces cannot be varied from hour to hour. Therefore the smelters desire large and regular shipments. In consideration for a guaranteed supply of a definite tonnage at a fixed rate, concessions are made and these shipments are purchased under more favorable terms than the small irregular shipments. A small shipment requires as much work for the assaying and general charges as a large one, making the cost of handling proportionately higher.

A comparison of the open schedules with the average contract schedule, under which the bulk of the ore is purchased, would not be favorable to the shipper, because a contract for a guaranteed tonnage of ore of a desired content at a specified rate would be given advantages over the open schedule which represents small and intermittent shipments.

The essential requirement for a lead smelter is an ore mixture, to be so apportioned that a slag can be formed, from which the recovery of the metal values is made. The metallurgist may often have to sacrifice good practice to obtain the greatest profit. Barren fluxes not only cost money but also take up space and reduce the capacity. When fluxes contain metals of value they may be classed as a low-grade ore and treated accordingly. These low-grade ores may be purchased under special and variable rates according to the requirements of the plant. The slag formed from smelting an ore or a combination of ores will contain appreciable amounts of gold, silver, copper and lead, as well as the other constituents, no matter whether all the original ores contained these metals or not.

In smelting sulphide ores, roasting is necessary in preparation for the blast furnace, thus involving an

extra expense of operation and an increased metal loss due to volatilization.

The quantity of fuel required varies from 8 to 12 per cent, depending upon the amount of sulphur, the lead on the charge, and the temperature of the formation of an easy running slag.

The principal products from the blast furnace are slag, flue dust and fume, matte, speiss and bullion. All of these products contain metal values, and with the exception of the slag, must be retreated for their recovery.

When the ores contain small amounts of copper, as in the case of smelting lead-copper ores, retreatment is necessary to bring the copper into a marketable form for further concentration. Each stage of the retreatment involves the usual losses so that the ultimate recovery is relatively small.

The final recovery of lead from the ore in the average copper-lead furnace charge requires from one and one-quarter to two smeltings. For the recovery of the copper in the form of high-grade matte, two and one-half to three smeltings are required.

In cases where the amount of lead on the charge is small, in the first operation, the recovery in bullion will be about 65 per cent, in by-products to be retreated about 15 per cent, lost in the slag about 10 per cent, and 10 per cent will be volatilized. Part of the latter may be recovered in baghouses, according to the plant equipment. For the efficient collecting of values in a lead smelter, the percentage of lead on the charge should be around 10 per cent. In order to smelt locally to the best advantage the ores of the average lead content such as produced, it is necessary to obtain lead from another source to bring the charge to the economic requirement.

During the five years' operation from 1912 to 1916 the Colorado smelters produced approximately 441,000 tons of lead bullion, 50 per cent of which came from Colorado ores.

In copper-lead smelting, zinc in the ore is detrimental. It decreases the fluidity of the slag and lowers the specific gravity of the matte, thereby interfering with the settling. Losses are also increased and furnace operations are hampered. All of the zinc in the ore is a loss to the lead smelter and the slag from the Colorado smelter carries from 5 to 10 per cent zinc. Other substances, such as alumina, manganese, lime and magnesia, act differently in the blast furnace and are penalized or credited accordingly. Iron is a necessary flux and has only that value to the lead smelter. It goes into the slag and cannot be economically recovered.

The best slags will contain from 0.002 to 0.005 of an ounce of gold, from 0.50 to 1.00 oz. of silver per ton, from 0.20 per cent to 0.30 per cent of copper, and from 1.0 per cent to 1.50 per cent of lead.

In the usual blast furnace practice with an 8 to 10 per cent lead on the charge, the slag made represents from 60 per cent to 65 per cent of the charge, or 1 ton of slag for each ton of ore smelted. The matte fall is held at about 10 per cent. The matte will contain approximately: gold 0.05 oz. per ton, silver 40.0 oz. per ton, copper 10 per cent, lead 15 per cent, zinc 10 per cent, and iron 40 per cent, together with other ingredients, such as silica, alumina, etc. The second matte contains 40 per cent copper or better.

The baghouse product will contain something like 40 per cent lead, 10 per cent zinc, and such other volatile metals as arsenic, antimony, cadmium, etc.

LOSSES AND REFINING

The losses incident to smelting are slag, volatilization, and mechanical. The losses of gold are small and are due to slag and mechanical losses. Smelter operations often show a gain in gold due to the non-payment for gold when less than 0.02 to 0.05 of an ounce in the ore. The loss in silver is in the slag and possibly a small mechanical loss, and is provided for by paying for 95 per cent of the silver content. The copper loss is in the slag. The lead losses are in the slag and in the flue dust.

In the usual practice the following summary of losses will be representative:

Gold	0.005 oz. per ton of ore treated
Silver	1.0 oz. per ton of ore treated
Copper	6 lb. per ton of ore treated
Lead	30 lb. per ton of ore treated

In addition to the actual metallurgical losses in the smelting operations, it is necessary that the schedule provide for the refining and marketing of the metals recovered. The cost of refining and marketing of the gold and silver is small and charged to the lead bullion. A representative bullion refining charge is $25.00 per ton, which includes freight, etc., or one and one-quarter cents per pound (1¼ cents) of lead. A representative refining charge on 40 per cent copper matte is $40.00 per ton, including freight, etc., or five cents (5 cents) per pound of copper contained in the matte.

The refining and freight charges for the copper in lead ores are not to be compared with similar charges for the copper in an ore when sold to a copper smelter, as the latter ships a practically pure product, paying no freight on the impurities. A lead smelter ships 10 per cent copper matte and the freight for the same distance, other things being equal, would be two and one-half times as great.

CONCLUSION OF INVESTIGATING COMMITTEE

By reading the evidence in Mr. Caldwell's statement, it will be found that certain questions are asked by producers of ore. These questions embody completely the complaint against the smelters and ore buyers of the state.

The answers to three of these questions are found in Mr. Whitaker's report. In the matter of refining and marketing charges the committee has no power to investigate any corporation outside of the boundaries of the state and there are no refineries in Colorado. Hence we must submit only such facts as we have found. It costs 1¼ per cent per pound of lead to transport and refine bullion. It costs 5 cents per pound of copper to transport and refine copper matte.

In the matter of returns upon the investment the risk is taken upon the turnover and not upon the original investment. Hence fluctuation of the market in metal prices is the dangerous end of the smelting business. And as pointed out in the letter from the executive committee of the Colorado Metal Mining Association, the returns figured upon the investment of $2,700,000 is approximately 27 per cent while when figured upon the turnover is less than 4 per cent.

The smelters contend that the valuation is not high enough; that while the valuation placed by Mr. Whit-

aker on the plants does cover the actual physical value, much money is expended in building and operating many experimental processes. Many of these have to be abandoned, and represent a total loss to the smelting companies, and hence the claim that a higher valuation should be placed in order to cover the item of depreciation. While there is, doubtless, much truth in this contention, the fact remains that the figures used by Mr. Whitaker are in excess of the assessed valuation of the plants. While it is probable the plants could not be reproduced at these figures at present, they could be in normal times.

In the matter of zinc ores, it appears that zinc smelting in Colorado is really not an important factor in determining the price of ore. Out of 1,167,205 tons of zinc ore and concentrates produced in Colorado, there was treated in Colorado zinc smelters only 79,755 tons, or less than 7 per cent of the total. The schedules and prices of such ores are made and determined in the great zinc smelting centers in other states. The price in Colorado for such ore is absolutely made outside of the state.

In the matter of lead ore—and that is the most important phase of the committee's work, for it is between the producers of lead ores and the buyers that most of the complaints have arisen—much may be said.

New schedules have been voluntarily put into effect by the smelters and ore buyers during the year 1917. It is admitted by many producers, and is doubtless true, that these schedules eliminate much of the ground of complaint. Nevertheless the basic complaint is with the schedule itself. The committee believes that no schedule based upon the unit and quotation system will ever be satisfactory to the producer. It is hard for many producers of ore to understand, and unfortunately the smelters and ore buyers make no strenuous effort to explain it to those with whom they do business. Hence grew the belief that they were unjustly dealt with. And the committee believes that such an impression will prevail as long as such schedules remain. In the opinion of the committee the introduction of a new and easy understood schedule would go far toward eliminating the complaints in this matter.

Another matter which is subject of much unfavorable comment is the fixed minimum of 5 per cent on lead ores. Mr. Whitaker's report shows the average contents of Colorado produced lead ores was 6.76 per cent. When under 5 per cent the smelters and ore buyers do not pay for the lead contents, the reason assigned being that the cost of treatment would balance the value of the ore. Mr. Whitaker in his report finds that it is necessary to send low-grade lead ores twice through the furnace, in which case, of course, the saturation of the slag is sure to occur. This causes a loss of 30 lb. to the ton or 1.5 per cent. The two operations would therefore consume 3 per cent of the charge or 60 per cent of the lead contents of a 5 per cent ore. Now the cost of treatment is borne by all the metals in the charge and hence only a portion of it should be borne by the low-grade lead ore. Doubtless this is a source of profit to the smelters.

The committee believes that either the minimum should be reduced to 3 per cent on lead ore, or that the producer should be given the opportunity to have his ores smelted and by paying the charges therefore receive the bullion on 5 per cent and lower lead contents.

In the matter of copper in ores, Mr. Whitaker plainly points out that on account of the lack of copper in most Colorado ores the saturation of the slag which is 6 lb. to the ton, takes most of the copper contents. In a lead smelter ore with copper contents must be treated with ore that has no copper and requires several operations, each entailing a loss by saturation of slag. While the minimum of 1 per cent or 1½ per cent is an arbitrary one it is probably founded upon results of experience. With three or four operations each entailing a loss of 6 lb. copper it can be plainly seen that 1 per cent copper in the original ore would be lost.

The committee believes that some system of licensing umpires should be established. Some competent authority should be established which would issue licenses upon proper examination, and with power to revoke such in case of dishonesty or improper return or careless work.

The complaint about equipment seems to be well founded. The committee believes that sampling works should be inspected and required to maintain a certain standard of equipment. This duty could be properly assumed by the Commissioner of Mines' department.

Government Controls Acetone Supply.—All of the acetone produced in the United States has been commandeered by the Secretary of War for the six months ending June 30, 1918. Supplies of this material can only be secured now by means of a permit. This may be obtained through Mr. C. H. Conner, Council of National Defense Raw Materials Division, War Industries Board, Washington, D. C.

William Gibbs Gold Medal.—Dr. William M. Burton, vice-president of the Standard Oil Co. of Indiana, has been awarded the 1918 William Gibbs gold medal by the Chicago Section of the American Chemical Society. Dr. Burton entered the employ of the Standard Oil Co. soon after receiving his doctor's degree from Johns Hopkins in 1889. He is best known through the Burton process of oil refining, which he developed and which was brought to the attention of the public in 1913. The process has been a big factor in increasing our gasoline supply.

Russian Production of Rare Metals.—The Russian Bureau of Mining reports that no bismuth was produced in Russia during 1916 (Commerce Reports). Antimony was produced in such small quantities that no statistics have been gathered. Of molybdenum (MoS_2), only 150 poods (5417 lb.) were produced, all of which was used for domestic purposes. The value cannot be ascertained. About 2000 poods (72,220 lb.) of tungsten, concentrated (60-65 per cent WO_3), was produced, the value of which is not given. The total amount was used in Russia. Since 1914 all bismuth, molybdenum and tungsten have been used for war purposes. In 1917 it is estimated that 6000 poods (216,680 lb.) of tungsten ore (65 per cent WO^3), 50 poods (1806 lb.) of bismuth ore (60 per cent Bi), and 200 poods (7220 lb.) of molybdenum (45 per cent Mo) were produced.

Saving in Transportation.—A considerable saving in transportation has been effected by fertilizer manufacturers by loading railway cars up to capacity, and then a little more. A freight car is not like a truck for heavy material to be pulled by a team of horses. The engine can pull it. And every car counts.

Synopsis of Recent Metallurgical and Chemical Literature

Log of An Electric Furnace.—E. A. SUVERKROP presents a description of the manufacture of electric-furnace tool steel as practised at the Watervliet works of the Ludlum Steel Company in the American Machinist of Feb. 28, 1918. Of considerable metallurgical interest is the following log covering one heat of an arc-furnace (style and capacity not given, but possibly making about seven tons per heat):

4:55—Charge started with furnace full of cold metal. Lime and mill scale added at start for dephosphorizing slag. Balance of charge added when the melting of the scrap provided sufficient room. The temperature of the melting stage is kept as low as possible to effectively remove the phosphorus.

9.16—Metal boiling; slag thinned by two shovels of silica. Slag rabbled.

9.24—Metal quiet and sampled for analysis. Slag black.

9:30—Lime added to slag to thicken, preparatory to removal.

9:35—Current off; black dephosphorizing slag raked off.

	Analysis of Melt	Analysis Desired
Carbon	0.59	0.95
Silicon		0.15
Manganese		0.20
Chromium	0.37	0.45
Phosphorus	0.018	0.015
Sulphur	0.025	0.012

9:39—Ten shovels of a mixture of lime, fluorspar and sand added to make second slag.

9:45—Slag sampled—was thin, showing some unfused lime.

9:53—Slag sampled—smooth and thin, color gray, condition reducing.

9:54—Metal sampled for analysis. Current off.

10:00—Slag temperature, 2573 deg. F.

10:02—Current on.

10:03—Five shovels of dope added to reinforce desulphurizing action of slag.

10:08—Slag sampled, condition good, as noted at 9:53.

10:10—Lime added to thicken slag preparatory to removal.

10:12—Current off.

10:14—Slag very thick and easily raked off. Metal 2570 deg. F.

10:20—Weighed amount of carbon added to metal.

10:22—Furnace doors luted to exclude air.

10:40—Furnace unsealed. Metal 2596 deg. F. Third slag made of seven shovels of mixture of lime, fluospar and sand.

10:52—Slag sampled, color gray and in excellent condition. Alloy added to bath.

10:59—Slag shows slight greenish tint, due to chromium.

11:02—Sample of slag and metal sent to laboratory for analysis. Slag temperature 2662 deg. F.

11:05—Current off. Green color in slag fading.

11:08—Slag 2652 deg. F. Current off waiting analysis. Ladles being preheated.

11:32—Slag too thin, four shovels lime added.

11:35—Slag in excellent condition, brownish gray color.

11:42—Additions of alloys to correct analysis made.

11:52—Test bar of metal forged to determine mechanical condition.

11:53—Metal agitated to perfect mixture.

11:55—Slag sampled, small quantity of lime added to bring it to exactly neutral condition. Temperature 2650 deg. F.

11:58—Small amount of ferro-silicon added to melt. Surface of melt quiet.

12:06—Additions of fluospar and silica to slag. Temperature 2690 deg. F. Current off.

As the metal was poured into the ladle, the temperature was taken as 2641 deg. F. and had dropped to 2640 when the first ingot was poured. Seventeen ingots were poured, each taking about 35 seconds. Temperature of the last ingot 2550 deg. F. The second ladle of metal came from the furnace at 2618 deg. F., the first ingot was poured at 2600, and, after thirty-five smaller ingots, the last was poured at 2575 deg. F.

Developments in By-Product Coking.—A paper on this subject was read before the December meeting of the Institution of Civil Engineers (British) by GEORGE B. WALKER. The author stated that the aim in recent designs was to secure better equalization of heat in all parts of the oven walls, to equalize the pressure between retort and heating flues, to reduce the time of coking, to facilitate inspection and regulation of all parts of the oven, to increase the yield of ammonia and benzol, and to economize in the use of gas for heating the ovens. The so-called "direct" process for the recovery of ammonium sulphate was shown to be more advantageous than the older practices, since the recovery of the nitrogen is performed without the use of condensers, coolers or scrubbers, consequently eliminating the need of a large quantity of cooling water with the attendant loss of heat, and being therefore independent of the temperature or the season. The plant is said to be no more expensive to construct or maintain than that for the scrubber process, and no noxious effluent is produced whether or not benzol is recovered.

The advantage of regenerative working is clearly brought out by the following generalizations: Assuming a battery of 50 modern by-product ovens, each having a capacity of 10 tons damp coal and carbonizing five charges per week, 2750 tons of coal (containing 30 per cent volatile and yielding at least 10,000 cu. ft. gas per tons) would be coked in that time. Running with waste heat boilers and no regenerators the exit gases at about 800 deg. C. should evaporate 500 gallons of water per hour, which would produce steam for non-condensing engines producing approximately 1200 hp. In addition there would be a small amount of surplus gas available. If, however, the ovens were equipped with regenerative checkerwork, the consequent use of highly heated air for combustion in the oven-flues reduces the consumption of scrubbed gas at this point sometimes to a figure as low as 40 per cent of that evolved. Supposing, however, that only 40 per cent of the gas was available for use in internal combustion engines, 2180 hp. could be produced therefrom, reckoning 30 feet of gas per horse-power-hour.

Steel Turnings and the Electric Furnace.—A note on this subject is given in the *Iron and Coal Trade Review* (London) for Dec. 21. 1917, by JOHN A. HOLDEN. He says that a few years ago steel turnings were not in very much demand, and good, clean turnings could be bought for 30s. per ton. The price to-day for the same metal is about £4 per ton, a figure which would, no doubt, have been exceeded but for the intervention of the Ministry of Munitions. He says the reason for this appreciation is not difficult to seek. The raw material for the manufacture of electric steel in the arc type of furnace consists almost entirely of turnings. The writer refers to those furnaces which are worked with cold stock. Incidentally, it may be added, in England very few furnaces are worked with liquid charges.

Fifty 3-ton electric furnaces would consume annually 150,000 tons of steel turnings. In addition, turnings often form a portion of a Siemens charge, and sometimes they are used in blast-furnace charges. For producing electric carbon tool steel mild-steel turnings from shells are in much demand. Nickel-steel turnings are used for the manufacture of nickel-steel ingots. With a suitable grade of scrap no addition of nickel may be required, because in any type of electric furnace there is no oxidation of nickel.

Similarly, nickel-chrome-steel turnings may be profitably converted into nickel-chrome-steel ingots. In acid-lined furnaces there is little or no loss of chromium; in fact, the reactions in this furnace are comparable to those of the crucible process. In basic-lined furnaces chromium may be retained or eliminated. In the former case the phosphorus would not be so completely oxidized, but nevertheless it would be confined to safe limits. It follows that for the cheap production of alloy steels, such as nickel and nickel-chromium, scrap turnings containing the necessary elements should always be used.

From an economic point of view, it is undesirable that alloy-steel turnings should be used in charges where the alloying elements are not necessary or desirable. Many engineering establishments do not keep all these varieties of scrap separate. They may religiously look after high-speed steel, but other alloy steels are mixed with plain carbon-steel turnings. In addition, the heaps of turnings sometimes become a dump for waste paper, or even worse refuse, etc. In those shops where the amount of scrap produced is very small, it may not be economically possible to separate the different varieties. Unfortunately, there are works producing weekly as much as 100 tons of turnings consisting of only two varieties, yet they do not trouble to keep them separate.

One example will suffice to illustrate the loss when nickel steel is used in charges where nickel is not necessary. Fifty tons of 3 per cent nickel steel scrap contain £300 worth of nickel. Taking 50 tons as a weekly average, it represents potentially £15,000 per annum. Whilst every electric steel smelter desires short heavy turnings, it has been found practicable to crush the lighter turnings and obtain results equal to those obtained by the use of the more expensive and weighty turnings.

Action of Caustic Liquors on Steel Plates.—Two interesting articles have recently appeared in the *Chemical Trade Journal and Chemical Engineer* (London) on the action of caustic liquors on steel plates. The subject is a very important one. In the first article (Dec. 22, 1917), C. E. STROMEYER discusses tests which he made with the idea of determining the effect of stresses and whether they were the cause of cracks. He experienced great difficulty in maintaining the test pieces in a strained condition. Pieces strained before being acted on by caustic would have no stress afterward. He states that this experience was very disconcerting, and may account for the results obtained by Professors Heyn of England and Parr of the United States who could detect no effect due to straining. The experience is, however, not without practical interest, as it points to a possibility that caustic liquor may cause a slacking back of rivets and caulked edges and lead to leakages. He thinks it will be no easy matter to devise tests which will maintain the samples in a strained condition, for in his experiments the stress had to be produced by the elasticity of the material, and if that fails the stress disappears. The case is different in a boiler, for there the stress is due to the boiler pressure, and though the caustic may relieve some stresses, as is shown by the flying off of rivet heads, the average stresses will be maintained, and some local stresses may even be increased.

Professor Heyn has published nothing on this subject, but wrote that he could not confirm the writer's results. Professor Parr, in the 94th Bulletin of the Illinois University, deals with the following points. He notes a change of electric potential if steel is immersed in caustic. The tensile tests showed a reduction of tenacity of about 30 per cent after treatment, but this reduction was not influenced by change of density of the liquor. The elongation improved about 10 per cent. The samples which were stressed during exposure behaved in the same way. Judging by his experiments and the description of Professor Parr's, the author thinks it doubtful whether his samples were really stressed while exposed. He also submitted some of his exposed samples to alternate (fatigue) stresses, and found about 20 per cent reduction in the number of reversals of stress before fracture occurred. The impact test results were about 10 per cent lower for the treated than for the untreated specimens. Professor Parr's most important results are his determination of the hydrogen which is absorbed by steel and iron when immersed in caustic soda, and, as it is well known that hydrogen makes certain steels very brittle, these determinations should explain the brittleness. However, as already stated, this brittleness seems to be produced only if the steel is stressed during exposure, but details of the conditions have not yet been determined. In the writer's experiments a change of density could not be detected.

The second article by ERNEST WORSLEY (Jan. 26, 1918) deals especially with vacuum evaporators. The author does not believe that the action of the caustic on the metal during tension is the sole cause of breakage, and cites numerous examples to prove this. He says the breakage occurs with other liquors, such as glue, and that the only sure way of preventing the breakage altogether is to use Mannesmann tubes. These tubes will not, however, resist corrosion and there appears to be some relation between the breaking of tubes and the internal wear, as tubes which break do not wear and vice versa. Another curious feature about the breaking of the tube is that the fracture always occurs at the

ends—never in the middle portion. The author concludes from the examples which he cites from plants in actual operation—that the breakage of tubes in vacuum evaporators is not due to caustic liquor any more than to any other liquid and can be prevented only by the proper selection of tubes, *i.e.*, tubes made of steel, which can be annealed without any sign of "shortness."

The Groch Flotation Machine.—A new flotation machine is described in the Canadian Mining Institute Bulletin, March, 1918, by F. O. GROCH and W. E. SIMPSON. As is seen by the sketch, the chief distinctive feature is a centrifugal impeller which has hollow hubs and is subdivided horizontally by a metal disc so as to

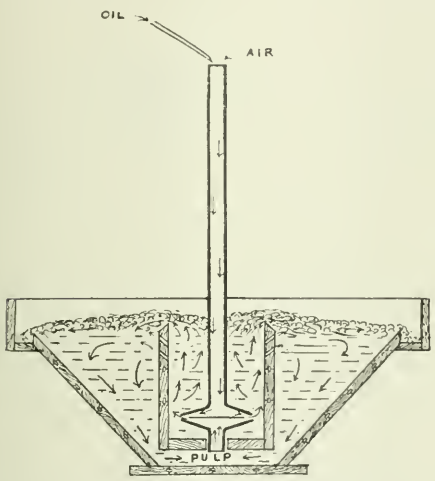


DIAGRAM ILLUSTRATING ACTION OF THE GROCH FLOTATION MACHINE

operate after the manner of a pair of centrifugal pumps. The pulp enters the treatment zone by being sucked up into the lower "runner" and ejected centrifugally at the periphery in a horizontal plane, where it must rise through a similar sheet of air and atomized oil (The system therefore gives most intimate contact between the ore particles and the finely divided air and oil.) The vacuum created at the discharge amounts to 2.75 inches of mercury at 450 r.p.m. and 6 inches at 750 r.p.m.

This machine eliminates the disadvantage associated with machines using the blade type of impeller of having to beat the air into the pulp by the creation of a deep vortex. Consequently the power consumption is quite low, a standard machine of six impellers with a capacity of about 55 tons of ore per day consumes 7.5 hp. The machine has been used on silver and molybdenite ores in the Cobalt region with marked success.

Basalt Lava for Filtration Purposes.—An article in Schweizerische Bauzeitung, Jan. 5, 1918, abstracted from Zeit. der Verein Deutscher Ingeniaur, states that experiments with finely crushed lava from extinct volcanoes in Central Germany have shown that this material is an excellent substitute for kieselguhr in the filtration of drinking water. Drs. Hambloch and Morziol take the lava deposits, grind them to a finely granulated condition, and wash them in a solution of sodium carbonate or in diluted hydrochloric acid. Roasting the granulated product preparatory to washing increases its cleansing qualities as well as its plasticity.

Recovery of Ammonia from Gas.—In the *Gas Record* for Feb. 27, 1918, Dr. JOHN S. UNGER, in an article on this subject, states that there are many good-sized coal-gas works in the country in which no income is derived from ammonia recovery. He says it should be the ambition of every manager of a coal-gas works, carbonizing 3000 tons of coal per year and over, to obtain an ammonia still and make concentrated gas liquor in small works, sulphate and aqua ammonia in larger works. He emphasizes particularly the advisability of using a modern high-grade still with adequate controlling devices. He describes a plant in Illinois which produced 36,511 lb. of concentrated ammonia in 1917 from 8166 tons of coal, or a yield of 4.5 lb. per ton. One year's operation paid for the cost of installation. When using two-thirds Kentucky and one-third Illinois coal the recovery is 5.25 lb. ammonia per ton of coal. It is estimated that we will need 150,000,000 lb. of ammonia this year for munitions and 40,000,000 for cold storage. Our production last year was 130,000,000 and we will have a severe shortage unless all sources are producing.

Recent Metallurgical and Chemical Patents

Dyes and Intermediates

Production of Beta-Naphthol Benzoate.—GUSTAV BLIEBERGER of New York patents a process which he assigns to the Anthony-Hammond Chemical Works of New York. He produces benzoyl chloride by heating together benzoic acid and phosphorus trichloride or penta chloride. The benzoyl chloride is then dropped on molten beta naphthol and any benzoyl chloride evaporated is caught in a reflex condenser. The beta naphthol benzoate thus formed is dissolved in alcohol and recrystallized. (1,254,970, Jan. 29, 1918.)

Vegetable Dye.—ISIDOR KITSEE of Philadelphia, Pa., patents a fast dye made by adding two metallic compounds to logwood. Chloride of zinc, copper ammonium chloride, chloride of tin, hydrochloric acid, and other compounds are added according to the color desired. (1,254,914, Jan. 29, 1918.)

Benzene-Naphthalene Dyes.—A patent issued to HEINRICH GRÜNHAGEN of Germany refers to the manufacture of dyes of the benzene-naphthalene acridin series. The dyes are made by heating a formyl derivative of a beta naphthylamine such as formyl-2-naphthylamine and a salt of a meta-diamine of the benzene series such as amino-dimethylaniline hydrochloride. The melt is dissolved in water and the dye precipitated with salt and zinc chloride. (1,255,740, Feb. 5, 1918.) Another patent issued to the above refers to halogenated dyes of the acridine series obtained by heating a halogen derivative of a formyl-meta-diamine of the benzene series with a salt of an aromatic meta-diamine. (1,255,739, Feb. 5, 1918.)

Apparatus

Evaporation Apparatus. — Dr. EDWARD HART of Easton, Pa., patents an evaporating apparatus particularly applicable to acids. A series of horizontal cylindrical tubes are placed in cascade as shown in Fig. 1.

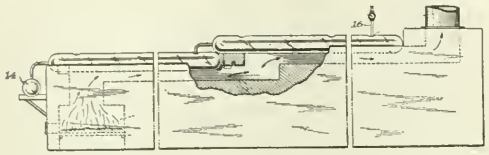


FIG. 1. SIDE VIEW OF HART EVAPORATOR

The tubes are either made of or lined with glass. The more or less dilute liquid enters the uppermost evaporators at a rate somewhat faster than it can be evaporated. The excess escapes into the next lower evaporators of the cascade and is finally delivered to the manifold 14, whence it is discharged by a pipe from 14 into any suitable receptacle, not shown. The evaporators being elongated, the liquid entering at one end of an evaporator has ample opportunity to mix thoroughly with the liquid (more or less concentrated) in the evaporator, before the overflow pipe at the opposite end is reached. The thorough mixing is important, and is due to several factors. First, the liquid entering any given evaporator is somewhat cooler than the liquid therein, thus causing a tendency of the incoming liquid to sink. Second, the convection currents are active and rapid because of the heating of the bottoms and the cooling effect of evaporation at the surface. Third, when boiling is permitted the ebullition agitates the liquid more or less strongly. The result is that if the supply by way of the pipes 16 is properly regulated the liquid in each evaporator is thoroughly homogeneous by the time it reaches the outlet pipe, so that the liquid escaping is no more and no less concentrated than the liquid remaining.

The evaporators and the receiving manifold at the end are simply laid on their supports and the discharge orifices of the supply and outlet pipes are free, so that any of the several vessels can be easily removed and replaced. While the total quantity of liquid in the system may be quite large, the quantity in any particular vessel may be relatively small. Breakage of a vessel is thus not the serious matter that it is in the case of a large receptacle, and replacement of a broken part is correspondingly cheaper and easier. If desired a dome may be arranged over the apparatus to collect the escaping vapors. (1,254,689, Jan. 29, 1918.)

Miscellaneous Processes and Products

Chlorine and Sodium Sulphate.—HERMAN B. KIPPER of New York City patents a catalytic process of producing chlorine and sodium sulphate. It is claimed that this process is much cheaper than the electrolytic or manganese chloride process. The process is based on the action of sulphur dioxide, water and oxygen, on sodium chloride. A catalyst such as ferric oxide is used in order to prevent the formation of hydrochloric acid. The temperature used is 400 to 600 deg. C. The process is carried out in a closed horizontal revolving iron cylinder similar to a roasting cylinder. There is an inlet tube at one end and an outlet at the other. Powdered sodium chloride is introduced through a hopper at the inlet and the catalyst is made up in the form of large balls so that they travel through the cylinder and are easily separated from the sodium sulphate formed. These balls are made from ground ferric oxide and sodium sulphate. The sulphur dioxide is introduced through the same tube as the salt. A flange on the inside of the drum raises the sodium sulphate formed and discharges it at the discharge end. The drum is continuously rotated. (1,255,020, Jan. 29, 1918.)

Drying Oils.—FELIX C. THIELE of Coffeyville, Kan., assigns a patent on drying oil manufacture to The Cudahy Refining Company of Coffeyville, Kan. Kerosene is treated with a halogen such as chlorine, then acidulated with acetic acid and treated with a metal such as zinc. (1,254,866, Jan. 29, 1918.)

Distillation of Coal.—CHARLES FOXWELL of Baltimore proposes to add to coal before distillation a substance which will not give up its entire water until a temperature has been reached at which all the desired products are given off. This is preferably accomplished by treating the combustible materials before they are distilled, with a water solution of calcium chloride and an oxygen-bearing compound of boron. This will retard combustion owing to the water being slowly expelled from the added solution, some of the water being retained even until after attainment of a temperature sufficient to volatilize all of the distillate sought after. In other words, by the time all the water has been expelled from the chemical compound the by-products will have been distilled over, and the fire may thereafter be regulated with respect to the product, for example coke, to be obtained from the base of the combustible material. Commercial borax ($Na_2B_4O_7$) serves well for the boron compound, and this being dissolved in water, together with calcium chloride, in the proportions of, say, 382 lb. of commercial borax to 918 lb. of calcium chloride of 72 per cent purity, will make the chlorine and boron molecularly equivalent. In practice, the material is springled with the solution in sufficient quantity, the material being thoroughly mixed or turned over during the treatment. When so treated, the material is ready to be distilled. (1,255,593, Feb. 5, 1918.)

Electric Furnaces

Induction Furnaces.—J. R. WYATT of Philadelphia, Pa., patents a variety of forms of induction furnaces (assigned to Ajax Metal Company) consisting of a large pool of molten metal heated by the circulation of hot metal driven through attached channels. These channels form the secondary circuits of enclosing transformers, and may be placed at various angles and in various combinations to the sides of the main pool or below it, and as many in number as required by the construction or by the number of phases of current used. As is shown in Figs. 2 and 3, which illustrate the simplest design, the secondary channels (36 and 37) are straight and intersect at the outer end in an acute angle (35). The length, width and height of the channel will be dictated by the total resistance desired in the secondary—using a given melt—the dimensions of the pool, and the location of the channels. The induced current in opposite directions in adjacent channels containing a molten conductor results in a motor

effect tending to separate the conductor, which face varies as the product of the currents in the two conductors and inversely as the distance between the parts of the molten metal affected. Consequently the motor effect is intensified at any angle in the conductor, increasing with the sharpness of the angle until counterbalanced by increase in friction at such a point. Joule effect is not very effective in comparison. A narrow channel intensifies the

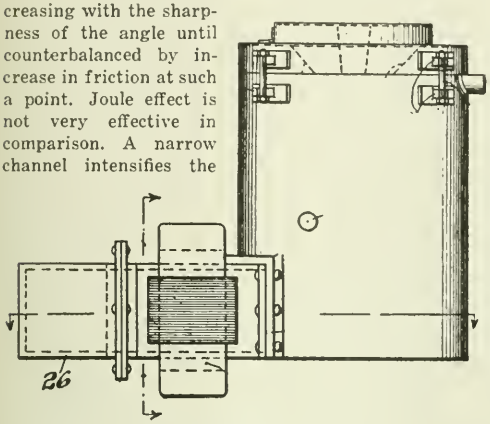


FIG. 2. SIDE ELEVATION

effect at the corner, but increases fluid friction, while a high channel receives a large transformer flux. In a brass furnace having a channel beneath the pool, a pouring heat of over 200 pounds, and a secondary current of 7000 or 8000 amperes, excellent results were had with a channel 18 inches long by 3 inches high by ⅝ inch wide.

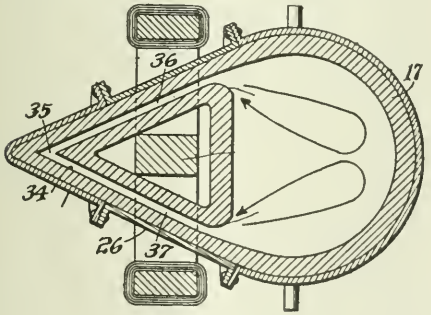


FIG. 3. SECTIONAL PLAN 2-2

In operation it is quite desirable to pour the initial charge from another furnace. The current is then turned on and heating of that charge and material added from time to time is effected by the secondary current. The hotter metal is driven out along the outer sides of channels 36 and 37, and is replaced by a flow of cooler metal from the pool passing along the inner sides of the same channel sections, heating the pool by the additional heat of the hotter metal withdrawn and stirring the pool by the flow, with a resultant intermingling of the hotter metal with that of the pool and gradual and nearly uniform increase of temperature throughout the pool. A narrow stream of hot metal ejected at considerable speed is much more effective than the same quantity delivered in a larger stream at a lower rate, since the stirring effect and immediate distribution obtained by the higher speed reduces the amount of mixing which must be accomplished by the slower Joule effect.

The casing 26 may be jointed at several points and separated by asbestos insulation to reduce the secondary current in the casing; or the furnace lining 17 and 34 may be itself a conductor of the first class in case a low-melting alloy of high resistivity is to be melted. In the latter case the furnace can be entirely drained at each cast; in the former, it must not be tilted to such a high angle as to break the molten secondary. The rounding of the junction (42) between channel and pool is necessary to reduce motor effect at these points. The furnace is particularly adapted for remelting chips or turnings of brass and other alloys. It is necessary to superheat these melts several hundred degrees above their melting points in order to pour good castings, in which case the vaporization of one or more components of the charge is usually quite serious. In this furnace any metal vaporized in the secondary channels is condensed before reaching the surface of the pool. (1,235,628, 1,235,629 and 1,235,630; Aug. 7, 1917).

Electrolytic Processes

Anode Suspension.—F. L. ANTISELL of Perth Amboy, N. J., points out the following difficulties in the manufacture and use of anodes with cast lugs: Thin lugs and anodes are hard to cast owing to chilling of the metal in the mold, even though it is desirable to pack as many into one tank as possible. Cast lugs are often warped, causing anodes to hang out of plumb and rough, causing poor electrical contact where they rest on the sides of the tank. Lugs are liable to damage in shipping, and cause a large amount of unelectrolysed scrap. They cannot be passed through rolls to smooth out irregularities. These objections hold in general anodes hung from hooks or links from rods, with the additional objection that one or two additional contacts are introduced, each consuming about 10 per cent of the total power used in refining.

His improved suspension is illustrated in Fig. 4,

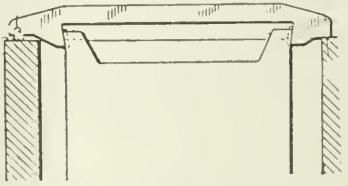


FIG. 4. METHOD OF ANODE SUSPENSION

where the suspension bar has V-shaped knife edges engaging in inclined slots in the edge of the anode. Good electrical contact at this point is insured by wedge action, giving up to four times the pressure of the weight of the anode, noting that by actual experience it has been found that within the range of current densities and voltages prevalent in copper refineries the reduction in resistance of the contact is about proportional to the pressure of contact. Using a suspension bar of refined copper has additional effect in reducing the resistance of the combination, which is claimed to reduce the contact loss from 10 per cent to 2½ per cent or less. (1,250,757, Dec. 18, 1917.)

Continuous Process of Causticizing Soda-Ash with Lime

IN VIEW of the fact that a majority of the paper mills in this country make their caustic liquors by an intermittent process of agitation and decantation, considerable interest attaches to a continuous process of causticizing soda-ash with lime, which has now been in operation for ten months at the mill of the Kingsport Pulp Corporation, Kingsport, Tenn.

The system employed in this mill is an adaptation of the well known metallurgical methods of continuous agitation and continuous counter-current decantation. The cyanide process of treating ores is analogous in many ways to the manufacture of caustic soda liquors, as there is, first, a chemical reaction to be carried on requiring agitation of the solids and liquor for a given time, resulting in a valuable liquor, and second, a valueless product from which the liquor must be recovered. From this

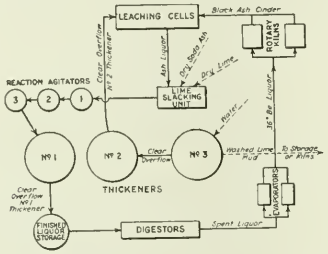


FIG. 1. FLOW OF SPENT LIQUOR

it will be noted that standard cyanide practice has been adopted, for in the Dorr continuous causticizing system continuous agitation is employed and the lime mud formed in the reaction agitators is continuously collected and washed in Dorr thickeners arranged to operate in a continuous and counter-current series. The agitating tanks are designed to give a retention period which will allow the reaction between the soda-ash and lime to come to equilibrium.

The feasibility of adapting this process to the manufacture of caustic soda liquors was demonstrated early in 1916 in a small-scale commercial plant capable of producing about 2½ tons of caustic soda per day. This was the largest plant of its kind that had been built at the time the Kingsport Pulp Corporation decided to adopt the system.

The Kingsport caustic plant was designed to produce 50 tons of 100 per cent NaOH per 24 hours in either a 10 deg. Be. or a 14 deg. Be. liquor. It has operated continuously for the last ten months and the ease of control, safety in handling and flexibility of the plant eliminate any fair comparison between the old and the new methods. Further, the absolute uniformity in strength of liquor produced permits the digester schedule to be maintained at maximum capacity.

Fig. 1 shows diagrammatically the flow of spent liquor from the digesters through the evaporators and recovery apparatus, and finally through the causticizing equipment. In plants as now designed the lime-slacking unit comprises a standard tube-mill and a Dorr classifier working in closed circuit, *i.e.*, the discharge of the tube-mill flows to the classifier and the coarse, unfinished product separated from the milk of lime is returned to the tube-mill, joining original feed. The finished product overflows the classifier. Soda-ash liquor, dry soda-ash and dry lime are introduced in this unit.

A mechanical feeder, adjustable to close control, delivers crushed lime from a bin to the tube-mill. By the operation of this continuous system of making milk of lime, all handwork is eliminated, the waste of lime and the labor required for cleaning out sand from slaking tanks is obviated, and absolute uniformity of the milk of lime is assured. Any unburned lime rock or silica is taken care of, as it is ground to such a fineness before leaving this system that it passes through the reaction agitators and thickeners mixed with the lime mud and causes no trouble. By the use of a classifier working in closed circuit with a tube-mill, the grinding efficiency is raised to a maximum, and small mills which require little power can be used so that continuous lime slaking by this method means a saving of power over slaking in tanks with paddle agitators.

The reaction between the soda-ash or soda-ash liquor and lime takes place in the three Dorr agitators. These machines are similar to those used in ore treatment, except that the whole mechanism can be raised so that the arms cannot get stuck in case of a shut-down. The agitators are equipped with covers and steam coils and operate at a temperature of 95 deg. C.

The mixture flows from the agitators to the series of Dorr thickeners where the continuous separation of caustic liquor is made. The thickened lime mud is transferred from the bottom of one thickener to the top of another by means of diaphragm pumps. The Dorrco diaphragm pump has an adjustable eccentric so that the length of stroke can be set from 0 to 3 in. The density of the thickener underflow is controlled by the number of strokes per minute, the length of the strokes, and by allowing air to enter the bowl compartment of the pump. These pumps have been used in caustic work for about two years, handling the thick, hot mud, and practice has shown that there is no upkeep cost except for an occasional change of diaphragm. The rubber diaphragms are readily replaceable without dismantling the pump, the average life being about two months.

All of the water entering the system is introduced at No. 3 thickener where the pump discharges its mud drawn from No. 2 thickener to the mixing launder. This launder is a steel trough with baffles laid in the bottom so that the lime mud and water are thoroughly mixed to form a uniform feed for the thickener. The clear liquor overflowing No. 3 thickener joins the lime mud from No. 1 thickener and is mixed with it in like manner to form a homogeneous feed for No. 2 thickener. The clear liquor overflowing No. 2 goes to the black-ash leaching cells and the effluent from these, after being built up with dry soda-ash, is used partly in the closed-circuit lime-slacking system, the balance going direct to the reaction agitators.

The percentage recovery of caustic soda by the washing process will depend upon the number of thickeners used and the amount of wash water that may be added, the latter being governed by the density of finished liquor that is required. When producing a 15 deg. Be. liquor and using three thickeners, a 99.7 per cent recovery of caustic soda is assured.

An interesting feature in connection with this process is the mathematical nicety with which it is possible to

calculate the percentage of the total caustic that will be recovered by a given number of thickeners.

Fig. 2 shows a conventional flow-sheet of a continuous causticizing plant based on the assumptions made

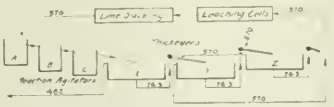


FIG. 2. CONTINUOUS COUNTER-CURRENT CAUSTISIZING PLANT

below. The figures given on the flow-sheet represent the tons of water flowing into and out of each unit.

Assumptions

Plant to produce 50 tons NaOH per 24 hours
Solution to be approximately 9.4 per cent NaOH (14 deg. Be.)
Black-ash leach-liquor to be recausticized
Agitation period 2 hours
50 per cent H_2O in thickener underflows
Yield to be 93 per cent
Na_2CO_3 ratio to be 10:6

Calculations

$$\underset{106}{Na_2CO} + \underset{56}{CaO} = \underset{62}{Na_2O} + \underset{100}{CaCO}$$

$$\underset{62}{C} \quad \underset{18}{E} \quad 50 \text{ tons}$$
$$Na_2O + H_2O = 2NaOH$$
$$\underset{80}{}$$

C : 62 = 50 : 80
C = 38.75 tons theoretical Na_2O = 93 per cent
F = 41.65 tons required Na_2O = 100 per cent

A : 106 = 41.65 : 62
A = 71.25 tons Na_2CO required

71.25 : B = 10 : 6
B = 42.75 tons CaO required

D : 100 = 42.75 : 56
D = 76.3 tons lime mud produced

E : 18 = 50 : 80
Water : solid = 1 : 1
E = 11.7 tons water required for reaction.
76.3 tons water lost with lime mud.

50 tons = 9.4%
532 tons = 100%
532 — 50 = 482.0 tons water with finished caustic liquor.
570.0 tons total water required.

Let X, Y and Z equal the value of the caustic liquor in each thickener in lb. of NaOH per ton of water.

By equating the expression for the amount of NaOH entering and leaving each thickener, the following simultaneous equations are obtained:

(1) 582X + 76.3X = 570Y + 100,000 lb. NaOH
(2) 570Y + 76.3Y = 76.3X + 570Z
(3) 570Z + 76.3Z = 76.3Y

Or

(1) 558.3X = 570Y − 100,000
(2) 646.3Y = 76.3X + 570Z
(3) 646.3Z = 76.3Y

Solving

(3)
646.3Z = 76.3Y
Z = .118Y

Substituting value of Z in terms of Y in (2)
646.3Y = 76.3X + 570 (.118Y)
579 Y = 76.3X
Y = .1317X

Substituting value of Y in tons of X in (1)
558.3X = 570 (.1317X) + 100,000
483.2X = 100,000
X = 207 lb.
Y = 27.5 lb.
Z = 3.28 lb.

The 482 tons of water going to storage with the finished liquor will carry 207 lb. NaOH per ton, or	99,751 lb.
The 76.3 tons of water going to waste with the lime mud will carry 3.28 lb. NaOH per ton, or	250 lb.
Total	100,001 lb.
Error due to neglect of decimals	1 lb.

Washing efficiency or recovery, 99.75 per cent.

Derivation of Above Equation

The total amount of NaOH leaving each thickener per 24 hours must equal the total amount entering it. Reference to the flow-sheet shows that 482 tons of water carrying X lb. of NaOH per ton leave thickener X and go to storage; 76.3 tons of water carrying X lb. NaOH per ton leave with the lime mud and enter thickener Y. Entering thickener X we have 570 tons of water carrying Y lb. NaOH per ton plus 50 tons of NaOH produced in the agitators. Entering thickener Y we have 76.3 tons of water with the lime mud from thickener X carrying X lb. NaOH per ton and 570 tons of water in the overflow from thickener Z carrying Z lb. NaOH per ton. Leaving thickener Y we have 570 tons of water carrying Y lb. NaOH per ton in the overflow, 76.3 tons af water carrying Y lb. NaOH per ton in the underflow. Entering thickener Z we have 76.3 tons of water in the underflow from thickener Y, carrying Y lb. NaOH per ton. The water entering thickener Z carries no value in NaOH, and hence 76.3Y is the only NaOH entering thickener Z. Leaving thickener Z we have 570 tons in the overflow carrying Z lb. per ton, and 76.3 tons in the underflow carrying Z lb. per ton.

Recent estimates made by the Dorr Company based on producing about 40 tons per day of caustic soda show that the total production cost exclusive of the cost of raw materials, is approximately 47 cents per ton of 100 per cent NaOH, with labor at 30 cents per hour and power at 2 cents per kw.-hr. This system of causticizing has been adopted by the Du Pont Engineering Company for a plant to produce 39 tons of caustic soda per day, which is to be built in connection with a plant now under construction for the United States government, and also by the Air Nitrates Corporation in connection with the plant they are building for the government at Muscle Shoals, Ala.

U. S. Trade with New Zealand.—The imports from American sources to New Zealand in 1915 were valued at $12,500,000, in 1916 at $19,000,000 and in the first six months of 1917 were $9,000,000. Paints and varnishes form an important part of the imports, while microscopes have also been sold in increased numbers. Petroleum products have also increased.

Personal

MR. EARL ADAMS, lately sales manager, powdered coal department, Bonnot Company, Canton, Ohio, and for some years in charge of gas producer work for The Power & Mining Machinery Co., has accepted a position as sales engineer for the Smith Gas Engineering Company and will shortly be located at Dayton, Ohio, where the new plant of the Smith Gas Engineering Company is nearing completion. A. B. MORRISON, JR., has also recently accepted a position with the company as sales engineer. Mr. Morrison was formerly with the Fort Wayne Electric Works and the Rathbun-Jones Engineering Company, and more recently with the John H. McGowan Company as Philadelphia representative.

MR. WILMER C. DUTTON of the Tolhurst Machine Works, Troy, N. Y., has been elected vice-president of the company and will be located at the New York office, at 111 Broadway.

DR. F. A. FAHRENWALD, consulting mining engineer and metallurgist, of Cleveland, will be in the West on professional business from about March 25 to May 10: the first two weeks in New Mexico and Arizona; the next two weeks in California and Nevada, and the remainder of the period in the Northwest.

MR. WILLIAM J. GROSS, formerly with the Sherwin-Williams Co., at Chicago, is now chief chemist of the Nordyke & Marmon Co., Inc., of Indianapolis, large manufacturers of automobiles and machinery. The Nordyke & Marmon Co. is doing extensive war work for the government.

Mr. ROBERT M. KEENEY, manager of the Ferro Alloy Company, Denver, Col., is acting as consulting engineer to the Anaconda Copper Mining Company on the manufacture of ferromanganese which the company is planning to start. He is in charge of construction and operation, but retains his connection with the Ferro Alloy Co., spending ten days per month in Great Falls.

DR. F. G. KEYES, formerly chief engineer of the Cooper Hewitt Electric Company, Hoboken, N. J., has received the commission of captain in the chemical section of the national army.

Messrs. OSTENBERG & CHRISTIANSEN, consulting chemical engineers of San Jose, Cal., have both taken up war work. Dr. Ostenberg has entered the Naval Flying Station at San Diego and Dr. Christiansen is a lieutenant on the medical staff of the navy.

MR. CURTIS PIGOTT, assistant superintendent of the Midvale plant of the United States Smelting, Refining and Mining Company, has resigned to become superintendent of the Herculaneum plant of the St. Joseph Lead Company, vice WILLIAM A. SMITH, resigned. Mr. Pigott was formerly connected with the Helena and Murray plants of the American Smelting and Refining Company, and is succeeded at Midvale by ROBERT WALLACE, metallurgist.

Messrs. J. L. SCHOELLKOPF, former president, and C. P. Hugo Schoellkopf, third vice-president, have withdrawn from the active management in the National Aniline & Chemical Co. They will continue as directors and stockholders. William J. Matheson was elected president. He is a director of the General Chemical Company, which is largely interested in the National Aniline Company. Dr. L. C. Jones of the Solvay Process Co. succeeds C. P. H. Schoellkopf as vice-president.

MR. R. C. SHUEY has been appointed assistant superintendent of Armour's Soap Works.

Dr. JULIUS STEIGLITZ, Mr. A. V. H. MORY and Mr. WILLIAM HOSKINS were the delegates of the American Chemical Society to the Congress of National Service, which was held in Chicago, February 21, 22 and 23. The congress was under the auspices of the National Security League.

Mr. W. L. TANNER, chief engineer of the Washoe plant of the Anaconda Copper Mining Company, has been transferred to Butte, where he will act as chief engineer of all the A. C. M. Co. operations in Montana.

Current Market Reports

Non-Ferrous Metal Market

Tuesday, March 26.—The markets for the most part have been quiet. Copper has been in good demand and tin continues scarce, with considerable demand. There has been plenty of lead offered and spelter has been considerably depressed in price.

Copper.—There has been a good demand for copper from consumers not engaged on government orders. Producers are not making large offerings, as a considerable part of their production is tied up until May and June. Prices remain as fixed by the government at 23.50 cents, producers' price, and 24.67½ cents, jobbers' price. Smelter production in January and February averaged 185,000,000 lb. monthly. Gains are expected in March and April.

Tin.—The tin situation continues very difficult. Straits tin is practically off the market, and such tin as can be brought brings fancy prices. As high as 85.50 cents has been paid for 99 per cent tin. Future Banca tin is quoted at 78.50 cents for April delivery. Chinese No. 1 is quoted at 77 cents for April delivery. There is reported to be 6300 tons afloat bound for this country, but arrivals have been slow and in small amounts for some time.

Lead.—Freer offerings have characterized the lead market during the past ten days. The trust price continues at 7¼c., New York. Independents asked 7¼c. to 7⅜c. A strike at the St. Joseph Lead Co.'s smelter at Herculaneum, Mo., on March 16, continued unsettled at the time of writing. There seems to be plenty of lead to take care of all requirements, but the demand continues strong and no impairment of the position of the market seems imminent.

Spelter.—In contrast to the other markets the spelter market has been dull and weak. Producers of spelter have had troubles of their own for such a long time due to overproduction that they would doubtless welcome price fixing by the government. Most producers are declining to quote at present prices, which are 7.30 to 7.55, New York, and 7.12½ to 7.25, St. Louis. The low prices may effect a decrease in production due to shutting down of some plants.

OTHER METALS

Aluminium, lb., 98-99 per cent. virgin, Gov't price	.321
Bismuth, lb.	2.50–2.75
Cadmium, lb.	1.50
Nickel, electrolytic, lb.	55.50
Silver, oz.	.92⅞
Platinum, oz.	108.00
Palladium, oz.	135.00–137.00
Cobalt, lb.	3.25–3.50
Magnesium, lb.	2.00
Quicksilver, Cal.	120.00
Quicksilver, Mexican.	115.00

The Iron and Steel Market

Shipments of finished steel products by mills continue to increase, but rather slowly. Traffic conditions on the railroads are still regarded as the limiting influence, but as time passes there is, almost insensibly, a change in the appearance of things, whereby it becomes doubtful whether this is the sole limiting influence. There is really a decided lack of pressure for deliveries on the part of some customers, and there is ground for suspicion that if shipping conditions enabled the mills to ship all their products at capacity they would be met by some customers with requests to curtail shipments. It is natural for mills to endeavor to place the best interpretation possible upon conditions, and to ascribe the curtailment in shipments wholly to traffic conditions is no more than natural, even though there may be other influences.

An outstanding feature of the market situation is that for the great majority of products there is practically no demand except that arising from the war. This, however, is not as indicative an item as might be supposed, for there is good reason to believe that the mills have on their books orders and contracts involving more than 12,000,000 tons of commercial steel, entirely apart from Government orders and orders from those who have Government orders to fill. That is a very large tonnage even for normal times, and when so much material is due to customers it is somewhat difficult to imagine who would be the customers who would

be anxious to buy large additional tonnages. In this connection it is important to bear in mind that owing to uncertainties of business as well as uncertainties of delivery, owing to the priority that must be given to war work, it is not the disposition of the trade, either buyers or sellers, to make engagements far ahead, as they frequently do in peace times. It was generally predicted, when the system of set Government prices was inaugurated late last September, that the trend would be strongly toward a clearing off of order books, the ultimate condition to be approached being one of almost hand-to-mouth buying in the case of everything except war material.

The genuineness of the contract business on books, how certain or uncertain it is to lead to specifications and actual shipping instructions, is very much in doubt. After an excited and advancing market the mills are always left with a large volume of contract business, not all of which is carried out, and at the present time the uncertainties are greater than is usual in such cases.

War Requirements

Indications as to the volume of war steel requirements are becoming somewhat more definite. The shipbuilding work is gradually getting into better form, and a rate of building 500,000 deadweight tonnage a month may be reached in the early fall, involving the consumption, altogether, of about 250,000 gross tons of steel per month, at least one-half of this being in the form of sheared plates. Even a much larger consumption would not tax the plate mills, however. In 1916 their output of sheared plates, ¼-inch and heavier, averaged a trifle more than 150,000 tons a month, and capacity is, or soon will be, close to 300,000 tons a month.

The car buying program, which will be arranged largely by the Railroad Administration, although the orders will be placed chiefly by individual roads, is being gotten into shape, with prospects that very nearly the full car building capacity of the country will be engaged. This, with locomotive building, may for a time absorb 300,000 to 400,000 tons of rolled steel, chiefly in the form of sheared and universal plates and structural shapes. An effort is being made to use universal plates to the fullest extent possible.

The shell steel program involves 2,500,000 tons for the second half of this year, against 1,500,000 tons ordered for delivery to the middle of next June, a small portion of the tonnage having been shipped in the closing months of last year.

At the moment there are large requirements for various construction items in connection with the war, including large tonnages of structural shapes and concrete reinforcing bars for docks and warehouses on both sides of the Atlantic, the object being to serve to the utmost the convenience of the ocean vessels, as well as the "port to front" road of the A. E. F. in France.

Iron and Steel Prices

At this writing there is no official information as to the decision of the War Industries Board as to what iron and steel prices shall rule after March 31, or how long the new prices, or the reaffirmed prices, are to be in force. Unofficial reports indicate that there will be some reductions, although nothing very extensive. There is ground for surmising, however, that a stronger effort will be made later by the Washington authorities for a somewhat lower level of prices. The present is rather an inauspicious time for argument in favor of price reductions, seeing that the mills have passed through a period of several months of exceptionally high costs, due to intermittent operations forced by the traffic situation. They are promised much better operations, but to date the improvement has not been sufficiently great or prolonged to be reflected in cost sheets, and thus it is largely in the form of promise. Two or three months hence the situation will be much clearer in this respect. Either operations will be on a much less abnormal basis or the promise of normal operations will be largely withdrawn.

Whatever the price limits established by the War Industries Board, there is a distinct probability that at times the maximum prices will be shaded as to some commodities, as it is evident that the dislocations produced by excessive war demands for certain materials on the one hand and greatly reduced peace or commercial requirements for other commodities on the other hand will cause some prices to be less firmly held than others. There will, in essence, be a reversal of the conditions obtaining in the first half of last year, when some commodities, such as plates, were in exceptionally great demand, and plate prices rose above their proper relation with prices for other commodities. Then all prices had a lower limit, based on the market value of semi-finished steel. Now all prices have an upper limit, that set by the Government. The former departures were above the normal average. Any departures in future will be departures downward.

Connellsville coke shipments have been steadily increasing and are now within about 10 per cent of the requirements of the furnaces depending upon Connellsville coke. Supplies of coal to by-product ovens are very nearly equal to requirements, and on the whole the production of pig iron promises to be ample for the requirements of steel mills, restricted as they still are to a considerable extent by inability to make shipments equal to their steel-making and steel-finishing capacity.

Plans are being completed for a thorough control of all the instrumentalities entering into the production and movement of Lake Superior iron ore in the coming season of lake navigation. Last season the effort was to secure maximum vessel movement, and this eventually congested the railroads serving Lake Erie ports. This year everything is to be made subservient to the railroad situation, so as to avoid congestion. The precise requirements of the blast furnaces will be ascertained, and no more ore will be brought down than will suffice them. The movement may be a trifle less than that of last year, as ore has accumulated while the blast furnaces were operating at much less than capacity.

Chemical Market

Coal Tar Products.—Trading was of slightly greater volume during the interval, although conditions continue to prevent large volumes of business from passing. The scarcity and high prices of some of the intermediates, coupled with the falling off in export trade, due to the disinclination of the authorities to issue licenses for many of the products, has considerable bearing upon the situation.

Benzol.—The large quantities offered on the market have caused a further reduction in price, and there is not a heavy demand even at present low prices.

Aniline Oil.—The position is slightly easier, due to the liberal offerings through second hands.

Beta Naphthol.—There has been a goodly volume of business passing in the technical grade, but offerings are sufficiently liberal, so that prices are unchanged.

Alpha Naphthylamine.—The demand has been heavier of late than for some time heretofore, and spot material is anything but plentiful.

Phenol.—There is not as great a demand as formerly and, though prices are quotably unchanged, the position is much easier.

Naphthalene.—Prices are well upheld, with offerings light and inquiries fairly plentiful.

Toluol.—Small quantities are offered on the open market, but the Government has commandeered such offerings as it is aware of, and it is unlikely that material will be offered liberally until the Government's needs are covered.

Aniline Salt.—Low offerings are a thing of the past, and producers are keeping the market well in hand.

Dimethylaniline.—Only a few producers are offering. The demand is fair and prices are slightly higher.

Paranitraniline.—Has been in heavy demand of late, and prices are higher, with offerings light.

Benzoate of Soda.—Is slightly easier, due to surplus offerings and light consuming demand.

Ortho Toluidine.—The scarcity of toluol has caused a curtailment in the production, and with an active demand prices have advanced.

Salicylic Acid.—Is offered liberally, and the demand is not heavy, so that it is possible to shade prices.

Para Nitro Phenol.—The production has increased, with

a slight falling off in consuming demand, and it is possible to shade prices.

HEAVY CHEMICALS.—Generally speaking, the markets for these products have been quite dull and lifeless during the past two weeks, and the tendency has been downward as regards values, but at the moment of writing a reaction has set in and in a number of instances an advance has been secured for a number of the important items.

Caustic Soda.—The lowest point that has been reached in months was recorded during the interval when spot 76 per cent solid caustic sold at 3.70. This situation was possibly due to the fact that shipments to this port have been unusually heavy of late and buyers have not appeared as rapidly as arrivals, in consequence of which there was a rather unusual amount of quick liquidation. Shipments from works have been maintained on a much higher parity than spot lots, and producers have never been inclined to meet the prices the second hand interests were establishing. At the moment of writing the market has assumed a very firm tone and there is considerable activity noted, with spot sales as high as 4.50 and producers quoting the same price from the works. There are rumors current of important developments that will tend to not only increase the output of caustic but of establishing a situation that will mean higher prices.

Soda Ash.—In sympathy with caustic the market slumped to a marked degree during the interval, and there were sales of spot rolling ash in bags as low as 2.50. The demand has been unimportant, but on the day this was written an important demand developed and there were sales at 2.75 and 2.80, with some sellers holding to 2.95 ex-store. Barrels have been strong, however, and important business has transpired at prices ranging from 3.15 to 3.25.

Bichromate of Soda.—The market has presented many ear-marks of manipulation, and there have been so many ups and downs during the fortnight that it has not been possible to record them. Sales have occurred at 24c., possibly 25c., but at the moment of writing spot material is available at 21½c., with May shipments at 20½c.

Bichromate of Potash.—Business has been dull, and minor transactions have occurred at prices ranging from 44c. to 45c.

Cyanide of Soda.—There has been no improvement noted and a domestic brand is available at 38c. to 40c., with the English material held at 35c. to 35½c.

Prussiate of Soda.—Considerable activity has been noted of late and sales have occurred at 37c., 37½c. and 38c. Sellers are now refusing to shade 38½c. and the prospects of a still higher market are bright.

Yellow Prussiate of Potash.—In common with most potassium compounds there is a weak market to report for this product. Spot offers have been as low as $1.20, although for shipment $1.22 and $1.25 is asked.

Formaldehyde.—Sales have occurred at 19¼c. but, in view of the fact that the important buying season is developing, sellers are firmer in their ideas and 19½c. is now asked.

Chlorate of Potash.—The market seems to have gone "bust." Spot stocks have accumulated to such an extent that a buyer can name his own price. Probably 1500 casks are available locally. While the nominal price is 40c. to 41c. for domestic business, sales have occurred at 32c., 34c. and 36c. A real buyer could possibly do 30c. for an important amount.

Chlorate of Soda.—In contrast the situation has been firm, and sales have occurred at 24c. and in some instances 25c.

Copper Sulphate. — While the situation is described as somewhat firmer, there are resales of standard brands at 9⅛c. to 9⅜c., and these depress the first-hand market, which is 9½c. Outside brands have sold at 8¾c. and 9c.

Sulphuric Acid.—Offerings have been more liberal, but are not abundant by any means. Acid in sellers' tanks works 66 degree brimstone is held at $42.00 and $44.00 drums. Some 60 degree brimstone acid has sold at $25.00 sellers' tanks works, with offers at $22.50 buyers' tanks works.

Muriatic Acid.—The situation has been quite firm, and there are important inquiries noted. For the 20 degree material 2¼c. is quoted, and for the 22 degree 2½c. cannot be shaded, with sales as high as 3c.

Nitric Acid.—Resale lots have depressed the market somewhat, and there have been offers at 8¾c., New York, for the 42 degree. Generally, however, producers will not shade 9c. Carboys continue scarce and restrict the movement.

Oleum.—There have also been more numerous offers of the 20 per cent oleum, and sellers have quoted $70.00 drums without finding a buyer. Earlier in the interval sales were reported at $72.50 and $75.00.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, MARCH 22, 1918

Acetic anhydride	lb.	1.35 — 1.50
Acetone, drums	lb.	Nominal
Acid, acetic, 28 per cent	lb.	.10 — .11
Acetic, 56 per cent	lb.	.12 — .12½
Acetic, glacial, 99½ per cent, carboys	lb.	.37 — .38
Boric, crystals	lb.	.13¼ — .14¼
Citric, crystals	lb.	.74½ — .75
Hydrochloric, C. P.	lb.	.08 — .08½
Hydrochloric, 20 deg.	lb	.02½ — .02¾
Hydrochloric, conc., 22 deg.	lb.	.02½ — 03
Hydrofluoric, 30 per cent, in barrels	lb.	.06 — .06¼
Lactic, 44 per cent	lb.	.13 — 15
Lactic, 22 per cent	lb.	.05½ — .06½
Nitric, 36 deg.	lb.	.08¼ — .08¾
Nitric, 42 deg.	lb.	.08¾ — .09
Oxalic, crystals	lb.	.44 — 45
Phosphoric, 47-50 per cent paste	lb.	.09 — 10
Phosphoric, ref. 50 per cent	lb.	.26 —
Picric	lb.	Nominal
Pyrogallic, resublimed	lb.	3.10 — 3 15
Sulphuric, 60 deg.	ton	25.00 — 27.50
Sulphuric, 66 deg.	ton	42.00 — 44 00
Sulphuric, oleum (Fuming), tank cars	ton	70.00 — 75.00
Tannic, U. S. P., bulk	lb.	1.30 — 1.35
Tartaric, crystals	lb.	.75 — .78
Tungstic, per lb. of W	lb.	1.80 — 1.90
Alcohol, sugar cane, 188 proof	gal.	4.93 — 4 95
Alcohol, wood, 95 per cent	gal.	1.35 — 1.38
Alcohol, denatured, 180 proof	gal.	.70 — 72
Alum, ammonia lump	lb.	.04 — .04¼
Alum, chrome ammonium	lb.	.18 — 19
Alum, chrome potassium	lb.	.19 — 20
Alum, chrome sodium	lb.	.12½ — .13
Alum, potash lump	lb.	.09 — .09½
Aluminum sulphate, technical	lb.	.01¾ — .02¼
Alumioium sulphate, iron free	lb.	.02¾ — .03¼
Ammonia aqua, 26 deg. carboys	lb.	.27 — .28
Ammonia, anhydrous	lb.	Nominal
Ammonium carbonate	lb.	.11 — .12
Ammonium nitrate	lb.	(Fixed price) .14
Ammonium, sulphate domestic	lb.	.07¾ — .08
Amyl acetate	gal.	5.00 — 5.25
Arsenic, white	lb.	.16¾ — .17¼
Arsenic, red	lb.	.65 — .70
Barium carbonate, 99 per cent	ton	80.00 — 90.00
Barium carbonate, 97-98 per cent	ton	65.00 — 67 00
Barium chloride	ton	65.00 — 85.00
Barium sulphate (Blanc Fixe, powder)	lb.	.03¾ — 04
Barium nitrate	lb.	.08½ — .11
Barium peroxide, basis 70 per ceot	lb.	.30 — .32
Bleaching powder, 35 per cent chlorine	lb.	.02¼ — .02½
Borax, crystals, sacks	lb.	.07¾ — .08¼
Brimstone, crude	ton	Nominal
Bromine, technical	lb.	.75 —
Calcium, acetate, crde	lb.	Nominal
Calcium, carbide	lb.	.14 — .14¼
Calcium chloride, 70-75 per cent, fused, lump	ton	23.00 — 27 00
Calcium peroxide	lb.	1.60 — 1 70
Calcium phosphate	lb.	.34 — .35
Calcium sulphate 98-99 per cent	lb.	.09 — 09½
Carbon bisulphide	lb.	.08 — 10
Carbon tetrachloride, drums	lb.	.15½ — .16
Carbonyl chloride (phosgene)		
Caustic potash, 88-92 per cent	lb.	.84 — .85
Caustic soda, 76 per cent	lb.	.04½ — .05
Chlorine, liquid	lb.	.15 — .18
Cobalt oxide	lb.	1.60 — 1.65
Copperas	lb.	.01¼ — .01½
Copper carboonate	lb.	.30 — .40
Copper cyanide	lb.	.75 — 78
Copper sulphate, 99 per cent, large crystals	lb.	.09¼ — 09¾
Cream of tartar, crystals	lb.	.58 — 60
Epsom salt, bags, U.S.P.	lb.	.03¼ — .03½
Formaldebyde, 40 per cent	lb.	.19½ — .20
Glauber's salt	100 lb.	1.25 — 2.00
Glycerine, bulk, C. P.	lb.	.68¼ — .69
Iodine, resublimed	lb.	4.25 — 4 35
Iron oxide	lb.	.13 — 15
Lead, acetate, white crystals	lb.	.17 — .18
Lead arsenate (Paste)	lb.	.15 — .18
Lead nitrate	lb.	.15 — .16
Litharge, American	lb.	.09¼ — 11½
Lithium carbonate	lb.	1.50 — 2 00
Manganese dioxide, U. S. P.	lb.	.70 — 75
Magnesium carbonate, technical	lb.	.10½ — 11
Nickel salt, single	lb.	.14 — 15
Nickel salt, double	lb.	.12 — 14
Phosgene, see Carbonyl chloride		
Phosphorus, red	lb.	1.40 — 1 50
Phosphorus, yellow	lb.	1.55 — 1 60
Potassium bichromate	lb.	.44 — 46
Potassium bromide granular	lb.	1.35 — 1 50
Potassium carbonate calcined, 85-90 per cent	lb.	.95 — 1 05
Potassium chlorate, crystals	lb.	.36 — 40
Potassium cyanide, 98-99 per cent	lb.	Nominal
Potassium iodide	lb.	3.75 — 3 80
Potassium muriate 80-85 p. c. basis of 80 p. c.	ton	340.00 — 350 00
Potassium nitrate	lb.	.27 — .31
Potassium permanganate (U. S. P.)	lb.	4 00 — 4 10

Potassium prussiate, red	lb.	2.80 —	2.90
Potassium prussiate, yellow	lb.	1.20 —	1 25
Potassium sulphate, 90-95 p.c. basis 90 p.c.	ton	Nominal	
Rochelle salts	lb.	.39 —	.39½
Salammoniac, gray gran	lb.	.16 —	17
Salammoniac, white gran	100 lb.	1 25 —	1.30
Sal soda	ton	20.00 —	25.00
Salt cake		— —	—
Silver cyanide, based on market price of silver	oz.	.54¾ —	.55
Silver nitrate	100 lb.	2.80 —	2 90
Soda ash, 58 per cent, light, flat	100 lb.	3.60 —	1 00
Soda ash, 58 per cent, dense, flat	lb.	.21½ —	.22
Sodium acetate	lb.	.02⅞ —	.03
Sodium bicarbonate, domestic	lb.	— —	—
Sodium bicarbonate, English	lb.	.21½ —	.24
Sodium bichromate	lb.	.05½ —	06
Sodium bisulphite, powd	lb.	.24 —	25
Sodium chlorate	lb.	.38 —	40
Sodium cyanide	lb.	.17 —	.18
Sodium fluoride, commercial	lb.	.02½ —	—
Sodium hyposulphite	lb.	2.50 —	—
Sodium molybdate, per lb. of Mo	100 lb.	Nominal	
Sodium nitrate, 95%	lb.	.35 —	.36
Sodium nitrite	lb.	.45 —	.50
Sodium peroxide	lb.	.03¾ —	.04¼
Sodium phosphate	lb.	.38½ —	40
Sodium prussiate, yellow	lb.	.04½ —	.05
Sodium silicate, liquid (60 deg.)	lb.	.02¾ —	.03
Sodium sulphide, 30 per cent., crystals	lb.	.05 —	.05½
Sodium sulphide, 60 per cent., fused	lb.	Nominal	
Sodium sulphite	lb.	.25 —	.35
Strontium nitrate	lb.	.06 —	.06½
Sulphur chloride, drums	lb.	.15 —	40
Sulphur dioxide, liquid, in cylinders	100 lb.	4.05 —	4 60
Sulphur, flowers, sublimed	100 lb.	3.70 —	3.85
Sulphur, roll	ton	Nominal	
Sulphur, crude	lb.	.23¾ —	21¼
Tin bichloride, 50 deg	lb.	.78 —	80
Tin oxide	lb.	.25 —	.30
Zinc carbonate	lb.	.12½ —	.13
Zinc chloride	lb.	Nominal	
Zinc cyanide	lb.	.14 —	16
Zinc dust, 350 mesh	lb.	.14 —	.15
Zinc oxide, American process XX	lb.	.06 —	07
Zinc sulphate		— —	—

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	30 —	35
Benzol, 90 per cent	gal.	— —	—
Toluol, pure water white	gal.	Nominal	
Xylol, pure, water white	gal.	.35 —	.50
Solvent naphtha, water white	gal.	.17 —	.22
Solvent naphtha, crude, heavy	gal.	.13 —	16
Creosote oil, 25 per cent	gal.	.33 —	.35
Dip oil, 20 per cent	ton	.29 —	.30
Pitch, various grades	lb.	8.00 —	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05 —	1.10
Carbolic acid, crude, 50 per cent	lb.	.60 —	.65
Carbolic acid, crude, 25 per cent	lb.	.35 —	.38
Cresol, U. S. P	lb.	.18 —	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00 —	1 25
Alpha naphthol, distilled	lb.	1.60 —	2.00
Alpha naphthylamine	lb.	.60 —	.62
Aniline oil, drums extra	lb.	.25 —	.26
Aniline salts	lb.	.32 —	.34
Anthracene, 80 per cent	lb.	.50 —	.65
Benzaldehyde (f.f.c.)	lb.	5.00 —	5.50
Benzidine, base	lb.	1 75 —	1.85
Benzidine, sulphate	lb.	1.40 —	1.50
Benzoic acid U. S. P	lb.	4 25 —	4 50
Benzoate of Soda, U. S. P	lb.	4.00 —	4.25
Benzyl chloride	lb.	2.25 —	2.50
Beta naphthol benzoate	lb.	10.00 —	12.00
Beta naphthol, sublimed	lb.	.85 —	.90
Beta naphthylamine, sublimed	lb.	2.65 —	—
Dichlor benzol	lb.	.12 —	.18
Diethylaniline	lb.	4.00 —	5.00
Dinitro benzol	lb.	.35 —	.40
Dinitrochlorbenzol	lb.	.40 —	.42
Dinitronaphthaline	lb.	.55 —	.60
Dinitrotoluol	lb.	.55 —	.60
Dinitrophenol	lb.	.46 —	.50
Dimethylaniline	lb.	.63 —	.65
Diphenylamine	lb.	1 00 —	1.10
H-acid	lb.	2 25 —	2 50
Metaphenylenediamine	lb.	2.00 —	2.25
Monochlorbenzol	lb.	.19 —	.22
Naphthalene, flake	lb.	.10½ —	.11
Naphthalene, balls	lb.	.12 —	.14
Naphthionic acid, crude	lb.	.40 —	1.50
Naphthylamin-di-sulphonic acid	lb.	1 00 —	1.10
Nitro naphthaline	lb.	.45 —	.50
Nitro toluol	lb.	.50 —	.55
Ortho-amidophenol	lb.	— —	—
Ortho-dichlor-benzol	lb.	.15 —	.18
Ortho-toluidine	lb.	1.25 —	1.50
Ortho-nitro-toluol	lb.	.75 —	1.00
Para-amidophenol, base	lb.	3.50 —	4.00
Para-amido-phenol, H. Cl.	lb.	4.00 —	5.00
Para-dichlor-benzol	lb.	.12 —	.15
Paranitraniline	lb.	1.25 —	1.30
Para-nitro-toluol	lb.	1.50 —	1.60
Paraphenylenediamine (base)	lb.	3.00 —	3.25
Para toluidine	lb.	2.25 —	2.50
Phthalic acid anhydride	lb.	4.50 —	5.00
Phenol, U. S. P	lb.	.53½ —	.55
Resorcin, technical	lb.	6.00 —	7.00
Resorcin, pure	lb.	9.00 —	10.00
Salicylic acid	lb.	1.00 —	1.10
Salol	lb.	1.85 —	2.00
Sulphanilic acid, crude	lb.	.32 —	.35
Toluidin	lb	2.50 —	—
Toluidine-mixture		75 —	85

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4.00 —	—
Corning, Ohio	bbl.	2.85 —	—
Somerset, Ky	bbl.	2.60 —	—
Wooster, Ohio	bbl.	2.38 —	—
Indiana	bbl.	2.08 —	—
Illinois	bbl.	2.22 —	—
Oklahoma and Kansas	bbl.	2.00 —	—
Caddo, La., light	bbl.	2.00 —	—
Corsicana, Tex., light	bbl.	.98 —	1.32
California	bbl.	1.35 —	—
Gulf Coast		— —	—

Fuel Oil

New York	gal.	.11 —	—
Pittsburgh	gal.	.07½ —	.10
Oklahoma-Kans	bbl.	1.50 —	2.35
Texas	bbl.	1.50 —	1.90
Los Angeles	bbl.	1.52 —	—
San Francisco	bbl.	1.45 —	—

Gasoline (Wholesale)

New York	gal.	.24 —	—
Boston	gal.	.25 —	—
Pittsburgh	gal.	.26 —	—
Chicago	gal.	.21 —	—
Oklahoma	gal.	.25 —	—
San Francisco	gal.	20 —	—

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.21 —	.22
Cylinder, light	gal.	.36 —	.38
Cylinder, dark	gal.	.35 —	.36
Paraffine, high viscosity	gal.	.40 —	41
Paraffine, 903 sp. gr	gal.	.33 —	.34
Paraffine, .865 sp. gr	gal.	.22 —	.23

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f.o.b. Florida	gal.	.44 —	—
Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.53 —	—
Pine oil, destructively distilled	gal.	49 —	.53
Pine-tar oil, sp. gr., 1.025-1.035	gal.	.35 —	—
Pine-tar oil, sp. gr., 1.025-1.035	gal.	.40 —	—
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.37 —	—
Pine oil, light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.26 —	—
Pine oil, heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.30 —	—
Pine tar, thin, sp. gr. 1.060-1.080	gal.	.40 —	—
Turpentine, crude, sp. gr. 0.980-1.000	gal.	19 —	—
Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990	gal.	.19 —	—
Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08	gal.	.19 —	—
Wood creosote, ref. f.o.b. Florida	gal.	.31 —	—

Vegetable and Other Oils

China wood oil	lb.	.21 —	22
Cottonseed oil, crude	lb.	.17½ —	.18
Linseed oil, raw, cars	gal.	1.55 —	1.57
Peanut oil, crude	gal.	1.37 —	—
Rosin oil, first run	gal.	.35 —	—
Rosin oil, fourth run	gal.	.66 —	—
Soya bean oil, Manchuria	lb.	.19 —	.19¼
Turpentine, spirits	gal.	44½ —	—

Miscellaneous Materials

Barytes, floated, white, foreign	ton	40.00 —	50.00
Barytes, floated, white, domestic	ton	30.00 —	36.00
Beeswax, white, pure	lb.	.56 —	.64
Casein	lb.	.22 —	.30
Chalk, light, precipitated, English	lb.	— —	—
China clay, imported, lump	ton	17.50 —	30.00
China clay, domestic, lump	ton	12.50 —	20.00
Feldspar	ton	8.00 —	12.00
Fuller's earth, powdered	100 lb.	1.00 —	1.50
Ozokerite, crude, brown	lb.	.65 —	.75
Ozokerite, American, refined, white	lb.	.75 —	1.00
Red lead, dry, carloads	lb.	.10 —	11¼
Rosin, 280 lb	bbl.	6.65 —	—
Soapstone	ton	10.00 —	12.50
Talc, American, white	ton	15.00 —	22.00
White lead, dry	lb.	09 —	.10

Refractories, Etc.

(F.O.B. Works)

		Nominal	Nominal
Chrome brick	net ton		
Chrome cement, Grecian	net ton		
Clay brick, 1st quality fireclay	per 1000	50.00 —	55.00
Clay brick, second quality	per 1000	35.00 —	40.00
Magnesite, raw	ton	30.00 —	35.00
Magnesite, calcined	ton	32.00 —	35.00
Magnesite, Grecian, dead burned	net ton	85.00 —	90.00
Magnesia brick, Grecian, 9x11½x2½	net ton	135.00 —	140.00
Silica brick	per 1000	50.00 —	60 00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f.o.b. Niagara Falls, N. Y	ton	160.00 —	—
	lb.	18.00 —	—
Ferrocerium	lb.	.50 —	—
Ferrochromium, per lb. of Cr	ton	250.00 —	—
Ferromanganese, domestic	ton	325.00 —	—
Ferromanganese, English	lb.	5.00 —	—
Ferromolybdenum, per lb. of Mo	ton	— —	—
Ferrosilicon, 75 per cent, f.o.b. N. Y	ton	170.00 —	195.00
Ferrosilicon, 50 per cent, carloads, del., Pittsburgh	ton	100.00 —	175.00
Ferrosilicon, 50 per cent, contract	lb.	2.30 —	2.35
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	7.00 —	—
Ferrouranium, f.o.b. works, per lb. of U	lb.	4.00 —	5 00
Ferrovanadium, f.o.b. works		— —	—

Ores and Semi-finished Products

Antimony ore, per unit	unit	1.60 —	1 75
Chrome ore, 48 per cent minimum, f.o.b. Cal., per unit	ton	1.50 —	1 60
Chrome ore, 43 per cent and over, New York, per unit	ton	1.50 —	—
Manganese ore, 48 per cent and over, per unit	ton	1.20 —	—
Manganese ore, chemical	ton	80.00 —	100.00
Molybdenite, per lb. of MoS_2	lb.	1.80 —	—
Tungsten, Scheelite, per unit of WO_3	ton	20.00 —	24.00
Tungsten, Wolframite, per unit of WO_3	ton	20.00 —	24.00
Uranium oxide, 96%	lb.	3.25 —	3.60
Vanadium pentoxide, 99%	lb.	10.50 —	—
Pyrites, foreign	unit	.17 —	17½
Pyrites, domestic	unit	.28 —	30

INDUSTRIAL

Financial, Construction and Manufacturers' News

New Companies

THE ALPHANO HUMUS COMPANY, Boonton, N. J. Capital, $4,000,000. To engage in the manufacture of fertilizers. Incorporators: John N. Hoff, Boonton; Richard Sellers, Bellevue, Del., and James E. Mantee, Portland, Me.

AMERICAN ALLOY AND CHEMICAL CORPORATION. Capital stock, $1,000,000. Directors: J. L. Boyle, G. A. Green, G. H. Beesemeyler, F. L. Riley, B. J. Quinn, A. J. Morse, J. I. Stevens.

THE AMERICAN INDUSTRIAL ENGINEERING COMPANY is a new enterprise with offices in the Monadnock Block, 53 West Jackson Boulevard, Chicago, which is headed by L. W. Lauren, president, and L. H. Bergman, vice-president.

Mr. Lauren was formerly vice-president of the Reynolds Wire Co., of Dixon, Ill., and Mr. Bergman was until a short time ago fuel engineer for the Midvale Steel Co. of Philadelphia, Pa.

The company, which is incorporated, will make a specialty in wire mill equipment, pulverized fuel installation, furnace work and fuel economy.

THE AMERICAN RECLAIMING & REFINING COMPANY, Bayonne, N. J. Capital, $250,000. To engage in the refining and reclaiming of metals. Incorporators: Bernard Rubine, Charles and Harry B. Dembe, 19 West Twenty-seventh Street, Bayonne.

THE ANDERSON COUNTY MICA COMPANY, Anderson, S. C. Capital, $100,000. To develop mica properties in Anderson County. Incorporators: J. J. Fretwell, N. J. Fretwell, Jr., and Raymond Fretwell, all of Anderson.

THE ARIZONA BAGDAD COPPER COMPANY, Dover, Del. Capital, $1,750,000. To mine for copper. Incorporators: Edward C. Christensen, E. B. Brownson, and Frederick C. Hary, all of New York.

THE R. M. BAILEY COMPANY, Dover, Del. Capital, $50,000. To manufacture iron and steel products. Incorporators: Charles B. Bishop, S. H. Baynard, Jr., and A. M. Fox, Wilmington.

THE BLUE RIDGE PAINT & COLOR COMPANY, Allentown, Pa. Capital, $10,000. To manufacture paints, varnishes, etc. A. W. Thompson is the principal incorporator.

THE BUCYRUS TIRE & RUBBER COMPANY, Buffalo, N. Y. Capital, $200,000. To manufacture automobile tires, tubes, etc. Incorporators: C. O. Henderson, Philip H. Heater, Bucyrus, Ohio, and George C. Riley, Buffalo.

THE DAY CHEMICAL COMPANY, Chicago, Ill. Nominal capital, $5,000. To manufacture chemicals and allied products. Incorporators: James B. Day, Robert A. Levener, R. H. Clinton, and Hilgard B. Young, Chicago.

THE DINGLE-CLARK COMPANY has been organized with offices at 536 Engineers Building, Cleveland, Ohio. This corporation will handle a complete line of motors, transformers, controllers, turbo-gears, and are in a position to install electrical equipment for any size plant with complete technical and financial responsibility assured. Mr. Howard Dingle and Mr. W. W. Clark were up to February 1, respectively, district manager and assistant manager of the Crocker-Wheeler Company in Cleveland.

THE EDMANSON & BATES COMPANY, Buffalo, N. Y. Capital, $150,000. To manufacture chemicals, etc. Incorporators: B. W. Stuart, E. M. Fitzmorris, and J. L. Kinney, Buffalo.

THE GREAT WESTERN LEAD & ZINC COMPANY, Miami, Okla. Capital, $100,000. To mine for lead and zinc. Incorporators: M. B. Rook, Miami; Edward Kesler, Carter, and J. G. Wherry, Commerce, Okla.

THE HART GLASS MANUFACTURING COMPANY, Dunkirk, Ind. Capital, $300,000. To manufacture glass and glassware of various kinds. Incorporators: Francis H. May, Thomas F. and T. Francis Hart, Dunkirk.

THE IDAHO COPPER COMPANY, Chicago, Ill. Capital, $250,000. To engage in a general copper mining business. Incorporators: William C., William O. Rouss and James A. Crotty, Chicago.

THE INDEPENDENT CHEMICAL COMPANY, Dover, Del. Capital, $4,500,000. To manufacture chemicals and allied products. Incorporators: W. B. Walsh, Brooklyn; J. A. Lyon, New York, and V. Harris, Pelham Manor, N. Y.

THE JEFFERSON GRAPHITE COMPANY, Birmingham, Ala. Capital, $20,000. To engage in the production of graphite. Incorporators: George R. Sincix, L. B. Gunville, and M. Hughes, Birmingham.

THE JOHNSON CHEMICAL COMPANY, Raleigh, N. C. Capital, $200,000. To manufacture chemicals and kindred specialties. Incorporators: James I. Johnson, James I. Johnson, Jr., and J. W. Cross, Raleigh.

THE KENSINGTON BRASS FOUNDRY & MANUFACTURING COMPANY, Philadelphia, Pa. Capital, $50,000. To manufacture brass, iron, steel, etc. Incorporators: Thomas W. Moore, L. V. Gillian and J. D. Levy, all of Philadelphia.

THE KRAYER CHEMICAL COMPANY, Elizabeth, N. J. Capital, $50,000. To engage in the manufacture of chemicals. Incorporators: Dr. Stephen S. Krayer, A. Krayer, H. Jacobs and Clarence S. Myer, Elizabeth.

THE LIBERTY LEATHER COMPANY, Dover, Del. Capital, $100,000. To manufacture leather and leather products. Incorporators: M. L. Horty, F. D. Buck and K. E. Longfield, Wilmington.

THE L. N. N. FOUNDRY COMPANY, Cleveland, O. Capital, $20,000. To operate a general foundry business. Incorporators: H. H. Neuman and C. E. Lyall, Cleveland.

LOWE BROTHERS COMPANY, Springfield, Ill. Capital, $47,000. To manufacture paints, varnishes, etc. Houston Lowe is president.

THE LUCKEY LEW LEAD & ZINC MINING COMPANY, Tishomingo, Okla. Capital, $25,000. To mine for lead and zinc, etc. Incorporators: George W. Dudley, C. W. Burton, Tishomingo and J. J. McKanna, Joplin, Mo.

THE LUTZ COMPANY, INC., OF NEW JERSEY, Camden, N. J. Capital, $125,000. To operate a general foundry and machine shop. Incorporators: William H. Lutz, Samuel Mason and Joseph S. Pedrick, Camden.

Construction and Operation

Alabama

EUFAULA.—Fire, on March 10, destroyed the entire plant of the Eufaula Cotton Oil Company, with total loss estimated at $65,000. The entire equipment of crushing and other machinery was also totally destroyed. The company has plans under consideration for the immediate reconstruction of the plant.

FLORENCE. — Operations are being rushed in connection with the construction of the new Government nitrate plant at Muscle Shoals, and it is expected that the first unit of the works will be completed and ready for operation by June 1.

Arizona

HUMBOLDT.—The Consolidated Arizona Smelting Company has commenced the construction of four Wedge mechanical roasting furnaces, each 22½ feet in diameter, having seven hearths for roasting and one for drying, the furnaces to be equipped with individual Cottrell dust-precipitators. When the new furnaces are completed, the plant will have a capacity of 600 tons of wet charge per twenty-four hours, or 150 tons per furnace per twenty-four hours, producing a calcine containing 8 per cent sulphur. The company is planning ultimately to double the capacity of the entire plant.

Arkansas

COTTER.—The Dixie Girl Mining Company is planning for the immediate installation of new equipment at its lead and zinc producing plant, including tables, compressors and air drills, to increase the present capacity of the plant. A. C. Barnhart is superintendent.

SPYKER.—The Southern Carbon Company is considering the immediate installation of new gasoline-making machinery in its plants at Spyker and Fairbanks.

California

JACKSON.—The Fortuna Mining Company is planning for the construction of a new concentration mill at its plant. The company has commenced the erection of a new electric power line at its works near Belleview.

CORCORAN.—L. B. Dapron is considering plans for the construction of a new four-stand cotton gin at Corcoran and a smaller plant at Fresno.

BAY POINT.—The Pacific Electro-Metals Company is experimenting with electrodes, and when satisfactory results are accomplished the company will take steps toward building the second unit of this establishment.

HERCULES.—One of the largest plants in the United States for the manufacture of trinitrotoluene for the army and navy is to be erected at once as an addition to the plant of the Hercules Powder Company at Hercules, Cal., according to advices received from Washington by the San Francisco Chamber of Commerce. The construction work on the plant is to be started at once and rushed with all possible speed. According to Warren H. McBryde, assistant superintendent for the Hercules Company, approximately 2000 men and women will be employed in the new plant.

CRUCERO.—The Tecopa Mines Company is planning for the construction of a new smelter at its local plant. Plans are also under consideration for a smelter at Tecopa. L. D. Godshall, Los Angeles, is in charge.

KLAMATH FALLS.—The Klamath Iron & Steel Company, recently incorporated with a capital of $20,000, has recently acquired a tract of three lots on Elm and Spring Streets as a site for the construction of a new foundry and machine shops. Contracts for the new works have been awarded. R. D. Cartensen is president; J. P. Fitzpatrick is secretary-treasurer, and D. M. Hall is general manager.

LOS ANGELES.—The Baker Iron Works, North Broadway, is planning for the immediate construction of a new two-story addition to its plant to cost about $5,500. Plans for the structure have been filed.

SAN FRANCISCO. — The Independent Steel Mills of Pittsburgh, Pa., which control the Liberty Steel Products Company, the Pittsburgh Steel & Pressed Car Works, and other corporations, are reported to be considering a number of sites on San Francisco Bay for the erection of a large new steel plant. P. G. Buerk is representing the companies.

Colorado

LEADVILLE.—The Star Consolidated Mining Company is making rapid progress in the construction of its new 300-ton mill, and the first 100-ton unit of the plant has been completed. The new plant will dress ore from the large bodies of low-grade iron-manganese deposits on the company's properties.

NEDERLAND.—Organization plans have been completed by the Malmo Mining & Milling Company, and it is planned to install the necessary machinery at the company's holdings. C. E. Bradenburg heads the company.

CLIMAX.—The new mill being erected at Hurfehr's spur by the Molybdenum Products Company is being rushed to completion, and it is expected that the plant will be ready for operation at an early date. A. B. Scott is manager.

DENVER.—The Queen City Foundry Company, Denver, Col., has placed an order for a one-ton Booth-Hall electric steel furnace to replace the converter equipment now being used by that company. The furnace has a holding capacity of three-quarters to one ton, and is rated at 300 kva. Power will be delivered to the furnace by the Denver Gas and Electric Company.

PUEBLO.—The Norcross Chemical Company of Denver is constructing a sulphuric and nitric acid plant here. The Kalbperry Corporation of New York are the consulting and designing engineers.

Delaware

WILMINGTON.—The E. I. duPont de-Nemours Company is planning for the construction of a new shell-loading plant on property recently acquired at Dundalk, Md.

Georgia

ATLANTA. — The Hec Manufacturing Company, 82 Marietta Street, is planning to increase the capacity of its plant by the installation of new equipment, to be devoted to the production of steel, brass and copper specialties.

Illinois

CHICAGO.—The U. S. Reduction Company recently purchased a tract of land of about 600 acres in Colorado. The present plans are to erect a large aluminium factory on this site.

CHICAGO.—The J. Greenbaum Tanning Company has recently purchased property at the northeast corner of Elston and Warsaw Streets, about 100 x 120 feet, for a consideration of $12,000. The property adjoins the company's tannery, and it is planned to construct a large new addition, for increased capacity, at a cost of about $100,000.

EAST CHICAGO.—The Sinclair Oil Refining Company has inaugurated operations in its new local refinery, oil having reached that point from the company's Oklahoma and Kansas properties through the new pipe line recently completed.

Indiana

TERRE HAUTE.—Colonel Gooderham of Toronto, and Captain Burton, an English officer, composing a British mission on manufacture of explosives, were here recently letting contracts and arranging for the opening of the old Commercial distillery as a factory for making acetone, the chemical base of cordite, an explosive, and "dope" for airplane wings. This will be manufactured from corn. Priority shipment of special machinery has been assured, and it is believed manufacture will be started within a few weeks. The final transfer of the plant from the John Edward Beggs interests to the British government were completed in New York.

WABASH.—Oscar Frosell, a Swedish-German chemist, who has been doing governmental experimental work here for some time, announced today that he has succeeded in making the first American magnelith, a material used for the deck floors of battleships. The material has been given rigid tests and cannot be checked or cracked by bullets. Magnesite, a magnesium cement, the base from which magnelith is manufactured, was obtained from the Pacific coast.

Iowa

CEDAR RAPIDS.—The La Plant-Choate-Williams Company is planning for the establishment of a new department at its plant and will install a complete new foundry building for the production of steel castings, etc. A five-ton open hearth furnace will be installed for initial operations. J. S. Williams will be in charge of the casting production department.

OTTUMWA.—The plant of the Morey Clay Products Company was recently damaged by fire to the extent of $30,000.

Kansas

BAXTER.—The Aksarben Mining Company is planning for the construction of a new concentration mill on the Cooper properties, recently leased by the company. John Voohees is president.

BAXTER SPRINGS.—The N. S. Sherman Iron Works Corporation is planning for the immediate construction of a new foundry and machine shop, about 40 x 80 feet, and 150 x 150 feet, respectively, both one-story structures.

TREECE.—The Commonwealth Lead & Zinc Company is considering plans for the erection of a large new mill at its properties. Extensive development work has been in progress for some time, and a good deposit at 260 feet depth has been opened.

Kentucky

LEXINGTON.—The Southwestern Petroleum Company has recently secured oil lands in Clay, Chiles, and Miller, Lee County, located on Cave Fork, Bald Rock, and Sinking Creek, for a consideration said to be about $40,000, and is planning for extensive development work.

WHITESBURG.—The Indian Refining Company has completed plans for the laying of a new pipeline, four-inch, from its new oil territory in Powell County to Ravenna, on the Kentucky River, a distance of about thirty miles.

Louisiana

DONALDSONVILLE. — The Norman Planting Company, which recently acquired the Belle Alliance and Evan Hall sugar plantations, is said to be planning for the construction of new additions to the refinery to provide for increased capacity. A. W. Norman heads the company.

Maryland

BALTIMORE.—Plans have been prepared by the Western Maryland Railroad Company, Continental Building, for the erection of a new one-story shop addition at its wheel works at Hagerstown. The structure will be about 30 x 35 feet, and is estimated to cost $10,000.

PERRYVILLE.—The Atlas Powder Company has begun the construction of a $6,000,000 plant for the manufacture of nitrate of ammonia from sodium nitrate and ammonium sulphate, according to announcement. The company is acting for the government, and at the end of the war the government will take over the plant. The company has 2000 men at work constructing the foundation for the plant on the site at Perry Point farm, at the junction of the Susquehanna River and Chesapeake Bay, near Perryville, Md. The plans call for the plant's completion by July 1, and afterward 1000 hands will be employed in manufacturing the nitrate for use in making explosives.

Massachusetts

SPRINGFIELD. — The Smith Foundry Company is planning for the removal of its plant to Greenfield, and will increase the capacity of the plant by the installation of new equipment.

WEST SPRINGFIELD.—The Gilbert & Barker Manufacturing Company is making rapid progress in the construction of new additions to its plant, to cost about $80,000. The capacity of the power house is also being increased.

Michigan

DETROIT.—Fire recently destroyed the four-story plant of the Monarch Steel Castings Company, which was engaged upon war contracts, with total loss estimated at $350,000. A number of valuable patterns were also destroyed.

MIDLAND.—The government has taken over the Dow Chemical works at Mt. Pleasant and Midland and will advance $2,000,000 for enlargement and new equipment in order to adequately supply the chemicals needed in the manufacture of munitions.

Mr. Dow will continue in the management as now, but otherwise it will be conducted as a government industry. A large number of new wells are to be put down, as fast as possible, between Mt. Pleasant and Midland, a pipeline will be laid between the two plants and a big power plant built somewhere between the two cities, which will supply light and power the whole length of the line.

GRAND RAPIDS.—The Grand Rapids Varnish Company, which recently acquired property adjoining its plant on Godfrey Avenue, has had plans prepared for the construction of a new addition, about 40 x 60 feet, which will be used as an extension to its enamel manufacturing department.

HOUGHTON.—Plans are under consideration by the Seneca Mining Company, operating the Seneca mine, for the immediate reconstruction of its machine and forge shops, recently destroyed by fire.

MARQUETTE. — The Cleveland Cliff Iron Company, Cleveland, Ohio, has commenced the reconstruction of the local alcohol refinery of the Pioneer Iron Works, which it controls. This plant was recently destroyed by fire, and the new works are estimated to cost about $250,000.

Minnesota

DULUTH.—The Zenith Furnace Company has taken out a building permit for the construction of a new concrete and steel gas holder to have a capacity of 1,000,000 cubic feet. The estimated cost of the work is $135,000.

Missouri

SENECA. — The Wyandotte Zinc Company is considering plans for the immediate construction of a new concentrating plant at its properties.

ST. LOUIS.—The Monsanto Chemical Works, 1800 South Second Street, has recently acquired the plant of the Commercial Acid Company, East St. Louis, Ill., for a consideration said to be in the neighborhood of $2,000,000. The company recently increased its capitalization to $5,000,000 for this purpose. The plant of the Commercial company includes a site of 114 acres, with twenty-five factory buildings, machinery equipment, etc., and it is planned to continue the manufacture of sulphuric acid, nitrate acid, carbolic acid, etc.

ST. LOUIS.—The Engel Paper Box Specialty Company, 1906 Pine Street, is planning for the installation of new machinery for the manufacture of paper cans and tubes in connection with its present box-making plant. W. W. Stroop is secretary.

Montana

BANNACK.—C. W. Stalling has recently leased the Hendricks gold mine, and is considering the construction of a new 5-stamp mill.

Nebraska

OMAHA.—The Henry R. Gering Company has acquired property at 1114-16 Farnam Street, and will make alterations and improvements in the structures for the establishment of a new chemical manufacturing plant.

Nevada

BULLION. — William Patterson and J. D. McFarlane are planning for the construction of a new local smelter for the handling of ore produced in Bullion and vicinity. F. G. Buick is engineer.

JARBRIDGE.—The Elkoro Mines Company has inaugurated operations at its new 150-ton cyanide mill. The new plant is operated entirely by electricity, which is generated at Thousand Springs.

New Jersey

EAST NEWARK.—The Ohio Cities Gas Company has acquired the plant of the Pure Oil Company, about 105 x 330 feet, on Passaic Avenue, and about 5 acres of land on Passaic Avenue near the Lincoln Highway, Kearny Meadows. It is said the property will be used for extensions.

NEWARK.—The Maas & Waldstein Company, Avenue R, manufacturer of chemicals, has recently taken out a building permit for alterations at its plant. The company is also planning for the erection of a new addition to cost $12,000.

BAYONNE.—Fire, on March 18, destroyed one of the new high pressure tubular stills at the plant of the Tide Water Oil Company, with loss estimated at $70,000.

CAMDEN.—The R. M. Hollingshead Company, manufacturer of oils, greases, etc., has taken out a building permit for the construction of a new brick addition to be located at Ninth and Market Streets.

BELLEVILLE.—The Lloyd Chemical Works, with plant in Holmes Street, is planning to purchase the site formerly owned by the Kent Motors Corporation, covering about 16 acres, from Washington Avenue to the Passaic River. It is understood that a large new chemical manufacturing plant will be erected by the company, comprising several three-story brick structures, to facilitate the handling of a $40,000,000 Government contract which the company holds. An expenditure of approximately $2,000,000 will be involved in the project.

WHARTON.—The Wharton Steel Company's iron ore mines, which consist of three mines—Scrub Oak, Oreland and Andover, have just been connected up. To connect these mines it was necessary to build six miles of 33,000 volt lines and one mile of 11,000 volt lines.

The Wharton Steel Company expects these mines to turn out about 2,000 tons of ore per day, which will take care of their furnaces at Wharton. The Steel Company owns the ore mines and also the railroad running from the mines to the furnaces. The mines run around 45 per cent before being concentrated and after being concentrated run about 65 per cent. At the present time The Wharton Steel Company is selling pig iron to the Bethlehem Steel Company and the Italian Government.

New York

OLEAN. — The chemical plants in this vicinity conducted for the distillation of hardwood have had their products acetate of lime and acetone, commandeered by the war department. The following plants are in this section: Vandalia Chemical Company, Straight Creek Chemical Company, Susquehanna Chemical Company, Lacka-

wanna Chemical Company, Keystone Wood Products Company, Smethport Wood Products Company, Corryville Chemical Company, Newton Chemical Company, Heinemann Chemical Company, Norweich Chemical Company, Smith Chemical Company, Minard Run Chemical Company, Lewis Run Chemical Company, and Custer City Chemical Company. Nearly all of these concerns have their main offices in Olean.

The 14 concerns, named above, employ 1000 at their plants and, in addition, at this season of the year keep 4000 men as teamsters and wood cutters, busy in the woods supplying chemical wood. The acetone produced by these concerns is largely used in the manufacture of high explosives, being indispensable for certain processes.

ALBANY.—A chemical plant costing $1,000,000 is to be constructed by the Federal Government at Mechanicsville to utilize the by-products of paper manufacturing plants of the West Virginia Pulp and Paper Company. The Government is to manufacture acetone, which is to be used to mix with varnish for coating airplane wings.

NEW YORK.—The Central Smelting & Refining Company, 220 Rider Avenue, is said to be planning for extension to its plant on property recently acquired on Third Street, Long Island City, about 75x150 feet.

YONKERS.—Fries & Fries, Cincinnati, Ohio, manufacturers of chemicals, etc., have acquired property comprising about one and one-half acres from Woodworth Avenue to the New York Central Railroad, to be used for the manufacture of waterproof coatings, syrups, etc.

LONG ISLAND CITY.—Plans have been filed by the Pittsburgh Plate Glass Company, for the construction of its proposed new two-story plant, about 265 x 270 feet, on Hunters Point Avenue. The structure will contain about 102,000 square feet, and is estimated to cost $200,000.

SYRACUSE.—The Savage Arms Corporation is considering the erection of a large addition to its plant to increase the present capacity by approximately 5000 machine guns per month. It is said that the company has Government contracts on hand at the present time which will occupy practically all of 1918

Ohio

MOUNT GILEAD.—The extensive new buildings of The Hydraulic Press Mfg. Company at Mount Gilead, Ohio, are now occupied and the plant is again in operation to its full capacity. The new equipment represents the most advanced types of metal working machinery available and is specially adapted for the building of hydraulic presses, pumps and valves.

CINCINNATI.—The Troy Metal Products Company, recently incorporated with a capital of $200,000, is negotiating with the Huenefeld Company, Spring Grove Avenue and Straight Street, for the occupation of the latter's plant to engage in the manufacture of munitions.

CARTHAGE.—The Pollak Steel Company is planning for the construction of a large new plant, to be devoted to the manufacture of equipment for torpedo destroyers. The new works are estimated to cost about $500,000, and will give employment to about 1000 hands.

CLEVELAND.—The Aetna Steel Castings Company has awarded a contract for the construction of a new foundry building, about 100 x 165 feet, at 2284 Scranton Road, Southwest, to cost $15,000.

COLUMBUS.—The Atlas Brass Foundry Company, 980 South Park Street, manufacturer of brass, bronze, and aluminum castings, and screw machine products, has taken bids for the construction of a new three-story brick addition, about 40 x 65 feet.

TOLEDO.—The Toledo Electric Steel Company, manufacturer of high speed and special alloy steels, is planning for the erection of a new steel mill building to increase the capacity of the plant. A 12-inch three-high tool steel bar rolling mill with drive, three water-tube boilers, 3-ton electric furnace, and 5, 3, 2 and 1-ton hammers will be installed.

Oklahoma

PICHER.—The Southwestern Missouri Mining Company is considering plans for the construction of a new 500-ton concentrating plant on its 40-acre lease of zinc properties between Picher and Treece, Kan.

QUAPAW.—The Kentex Mining Company is planning for the construction of a new mining and milling plant at its properties, to cost about $100,000. S. C. Kennedy is manager.

QUAPAW.—The Bethlehem Zinc Company is considering the erection of a new mill at its properties. T. Wade is president.

QUAPAW.—The Lucky Joe Mining Company has commenced the construction of a new 250-ton concentration plant at its lead and zinc properties. J. P. Matthews is manager.

Oregon

GOLD HILL.—O. C. Runnals, Seattle, Wash., and associates, have acquired the Utah Mining Properties, located about twelve miles from Gold Hill, and are planning the erection of an electric transmission line, about five miles long, to connect with the lines of the California-Oregon Power Company. It is proposed to equip the mines with electrically operated machinery.

Pennsylvania

PHILADELPHIA.—The Gorgas-Pierie Company, 126 East Allen Street, manufacturer of seed oils, etc., has awarded a contract to the Turner Concrete Steel Company, 1713 Sansom Street, for the construction of a new two-story brick and concrete addition, about 55 x 75 feet, to cost $15,000.

PITTSBURGH.—The plant of the Walker-Stratman Company, Herrs Island, near Pittsburgh, was destroyed by fire on March 8. The company was engaged in the manufacture of glycerin for Government use in high explosives.

RITTERSVILLE.—The Noequa Chemical Company, recently incorporated in Philadelphia with a capital of $450,000, is considering the construction of a large local manufacturing plant.

TYRONE.—The West Virginia Pulp & Paper Company has commenced the construction of its proposed new local plant, comprising eight manufacturing buildings. The new works are estimated to cost $500,000. The George A. Fuller Company, 949 Broadway, New York, is the contractor.

NEW CASTLE.—A nitric acid plant costing $1,000,000 will be erected as an addition to the Covert's station powder plant of the Grasselli Chemical Co. Construction work has already started.

SCRANTON.—The American Color Company, which is constructing a $50,000 plant at Scranton, Pa., will begin the manufacture of direct cotton colors about April 1. Benj. C. Warnick is president, Clifford Stone Cooley, vice-president and general manager, and E. B. Jermyn, treasurer

Tennessee

COLLINWOOD.—The Government is building a large wood chemical plant in Collinwood to procure acetate of lime and wood alcohol for munitions. Collinwood is located in the center of Wayne County, and the center of a wilderness of timber. Contract for the plant was made with the Tennessee Valley Iron and Railroad Company, a Pittsburgh concern, which owns 90,000 acres of land in this county, and which will operate the plant for the Government. The plant is to cost $2,000,000 and be completed in eight months. Thompson-Starrett Company of New York will erect the plant. This will be the largest plant of its kind in the world and will use 200 cords of wood a day.

The Government will require all the products except the charcoal which will be used in the manufacture of pig iron.

DUCKTOWN.—The Tennessee Copper Company, 11 Broadway, New York, is planning to increase the capacity of its local sulphuric acid plant to 3,000,000 tons annually.

MEMPHIS.—The Webster-Warnock Chemical Company is having plans prepared for the reconstruction of its chemical manufacturing plant recently destroyed by fire with loss estimated at $25,000.

HADLEY'S BEND.—The United States Government, War Department, is planning to have a daily capacity of 1,000,000 pounds of smokeless powder and 1,000,000 pounds of guncotton at its new local explosives plant, which will represent an expenditure of $100,000,000 instead of $60,000,000 as previously announced. The duPont Co. has charge of the construction work.

KINGSPORT.—Information has been received of the location of an alcohol plant at Kingsport, Tenn. The Government is behind the enterprise which, when completed will cost $1,250,000, and will give employment to a thousand men. It is understood that the product of the plant will be used for polishing gunstocks for which maple and beech lumber is used. The by-product will be converted into charcoal which has a ready market at the time. Already 35 acres of land have been secured and work will go forward at once.

Texas

BROWNWOOD.—Rapid progress is being made by the Gotebo Oil, Gas & Refinery Company in the construction of its new local refinery, and it is expected that the plant will be in operation at an early date.

BROWNWOOD.—The Brown-Ard Refining Company, Ardmore, is considering the construction of a large new oil refinery on a tract of land comprising 26 acres on the Hall property west of Brownwood. The new plant will have an initial capacity of about 1,000 barrels daily.

ROCKDALE.—Henry M. Butler, Hillsboro, and associates, have completed arrangements for the development of a large bed of lignite recently purchased, near Rockdale. It is planned to mine the fuel by means of steam shovels.

Utah

SALT LAKE CITY.—The Western Silver Mines Company, operating in Mineral County, Nevada, has announced that plans have been completed for the construction of the first unit of its proposed 500-ton concentrating mill at its properties. The holdings of the company consist of ten claims and a mill site, aggregating 220 acres, the ore consisting of a highly siliceous vein material carrying values in gold, silver and lead. A. L. Jameson, of Los Angeles, Cal., is president.

SPRINGVILLE.—The Springville-Mapleton Sugar Company has commenced the construction of its new local sugar refinery.

OGDEN.—The Ogden Portland Cement Company, operating the plant at Baker, Utah, twenty-five miles north of this city, will manufacture potash, if the results of the experiments now being made prove satisfactory. This is the announcement made at the offices of the company, here. The experiments are being conducted at the plant by Manager H. C. Day and chemical experts have been brought here from California, probably from the Western Precipitation Co., of Los Angeles, who install the Cottrell process.

Virginia

NORFOLK.—The Linde Air Products Company, New York, is planning for the construction of a new local plant to cost about $50,000.

NORFOLK.—The Vithumus Corporation is having plans prepared for the construction of a new plant for the manufacture of fertilizer at South Norfolk.

PORTSMOUTH.—The Portsmouth Cotton Oil Refining Corporation, which recently increased its capital from $650,000 to $1,000,000, has awarded a contract to Nichols & Linderman, Seaboard Bank Building, Norfolk, for the construction of a new two-story factory building, about 100 x 150 feet, to cost $30 000.

STAR TANNERY.—The Mineral Ridge Manganese Corporation, recently incorporated with a capital of $250,000, has commenced the development of its 700-acre tract recently acquired. At the present time the company has a daily capacity of 20 tons of manganese, which it is planning to increase to 60 tons. W. B Shaffer, Nazareth, Pa., is president.

Washington

BELLINGHAM.—The Boundary Red Mountain Mining Company is planning for the immediate reconstruction of its power plant recently destroyed by fire. It is expected that the new plant will be ready for operation during the coming fall

LOON LAKE.—The Loon Lake Copper Company is planning for a bond issue of $40,000 to provide for the construction of a new mill, including flotation and grinding machines.

OROVILLE.—The Hudson Consolidated Mines Company has had plans prepared for the construction of a new 150-ton ball mill and flotation plant at its properties. Estimated cost of the structure is $75,000.

SPOKANE.—The Rhodes Harvester Company has had plans prepared for the immediate construction of a new foundry addition, about 60 x 100 feet, to its plant to cost about $10,000. The company is also planning for extensive improvements to increase the present capacity.

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Copper in Converter Slags

THE tourist with metallurgical proclivities visiting the copper smelters in the Rocky Mountain region is struck by a very general similarity in most of their machinery and methods. This doubtless is a result of the evolutionary development of copper metallurgy during the last twenty years. Take, as an instance, the roasting department. It utilizes a furnace which is essentially a steel tank containing multiple superimposed hearths through which the ore is rabbled by cooled arms fixed to a rotating central shaft. Of course many variations in detail design may be noted, and the furnaces may therefore variously be called McDougall, Wedge, or Herreshoff. Furthermore, differences appear in methods of charging ore, removing calcine and handling smoke in adaptation to the general requirements of the plant and its surroundings. Still it is apparent that this type has exclusively supplanted the earlier heaps, stalls, straight-line and curved hearths, sintering pots and Brückner cylinders as a roaster for copper ores.

The great variation in the methods of handling converter slag is consequently quite suggestive of the diversity of opinion which prevails on this subject, and indicates that some, if not many, of the solutions have an insecure foundation on financial economy and metallurgical fact. Probably based on the idea, implied if not admitted, that the copper in these slags is held in complex compounds which cannot be broken up in the approximately neutral reverberatory furnace, many plants allow the slag to solidify and resmelt it in a blast furnace. The accompanying slag-casting machine may be a series of stationary or tilting pans, a chain of molds traveling in a straight line or about a "merry-go-round," or again the slag may be poured out in a thin layer on an ore bed, or even into a sump or a hole in the ground to be reclaimed later by steam-shovel or grab-bucket. If the plant possess no blast furnaces, or the management is willing to brave slag loss to save coke, the slag is charged into reverberatories. Here again considerable variation is noted; cars may be switched to the charging track and the liquid slag poured through the furnace roof with the maximum fall possible; pots may be poured by cranes into slag launders delivering the slag through the side or back wall at a moderate head, or finally cold skulls may even be used for "manger" filling.

After noting this diverse practice, it is not surprising to find little real information available on the fundamental question "How is the copper held in the converter slag?" or the broader one "How is copper held in a furnace slag?" If the intense oxidizing atmosphere in the converter forms copper oxides and silicates, then doubtless a powerful smelting process would be needed

for its retreatment, and hot-charging into the reverberatory would merely dilute the slag loss. However, Laney of the United States Geological Survey found after microscopic investigation that the valuable metal even in good furnace slag is mostly in a suspension of minute spheres of matte; on this basis the whole question of recovery becomes merely one of "hindered settling" wherein the relative specific gravities of the matte and slag, the size of the particles of matte, but more especially the viscosity of the slag itself play their separate roles.

Converter slags can be run so high in magnetite as to be unworkably sticky. If the viscosity of furnace slag is similarly affected by a more modest increase in the iron content the contention of the metallurgists at the El Paso plant is easily explainable, that in a reverberatory furnace a low-iron slag will be low in copper, whether or not converter slag is charged. Again, Green's idea that converter slag should be poured into a bath from a considerable head is justified, since the large body of matte would tend to wash out the smaller particles by actual physical contact. Lastly, good recovery might be effected by mere settlement, if sufficient time be given at a temperature high enough to maintain a mobile melt. Whether this final alternative is economically possible is a question of such importance as to warrant a considerable expenditure in research. In any event, it would seem that a study of the relation of iron content and temperature to the viscosity of a molten slag would pave the way toward a proper understanding of many furnace problems, as well as to a rational solution of the ever more pressing and vexing question of the proper elimination of iron from the smelting system.

Fats From Petroleum

"WHY," asked the Italian savant, Professor Giacomo Ciamician, "should we use only the fossil energy of the sun?" Why drill for oil and run it through pipe lines and distill it and chlorinate and oxidize and reduce and worry and fret over making fatty acids out of it, when their glycerides are already made for us over beautiful, waving fields of corn and soya beans and on tropic sands in cocoanuts,—not to mention only a few of the rich sources of supply now at hand?

Nature's chemistry book is planned on different lines from ours. She does not bother about the elements as much as we do. She regards the elements as a sort of cosmic underwear and elemental stuff is displayed only occasionally. In natural synthesis the units are seldom elemental. Nature also has physical chemistry in the back of her head and she uses it as we use the multiplication table, without counting her fingers. It is the same with the phase rule, and again she has mathematics enough and all by heart to meet any number of phases. Then she applies the rule to men and women, to our utter confusion. In technology she introduces the element of aesthetics and makes her chemical factories, which are forests and fields, things of unspeakable beauty. Usually we hide our chemical factories as much as we can so that the least number of people may see them, which is entirely right and proper—since they look as they do. Again, Nature will not endure a stink, permanently. We make them and live in them.

It seems more than likely that even if peace ever comes again, the edible fats of mankind will be of vegetable rather than animal origin. It stands to reason that fats from soya beans and from other vegetal sources are more economically produced than by feeding corn to hogs and then killing the hogs. It even seems more economical to press seeds than to buy industrial reagents and then to burn trainloads of coal to recover them.

The greatest advances that have been made of late in the development of vegetable oils for human consumption have been with cocoanut oil, of which the imports into this country increased from 64,349,308 pound in 1916 to 163,091,004 in 1917. The soya bean industry is promising and peanut oil is here to stay. Cottonseed oil has long been a great American institution and corn oil is another aspirant for high office in human economics.

So, while we would not stay the hand of any one engaged in legitimate research, we have our favorites for encouragement. Just now we should like to see greater encouragement and interest in the work of biological chemists. Someone has computed that the application of the inventions of Louis Pasteur to industry produced in three years sufficient wealth to pay the indemnity demanded by Germany of France after the Franco-Prussian war. Biological chemists produce the real labor-saving inventions. With their yeasts and ferments and miscroscopic critters they train vast armies to work for us. It takes time to eliminate the unfit and to train the fit; but they work beautifully when they are started right. We have inherited ethyl alcohol by this process, but it looks as though acetone also were coming along pretty fast, and on a big commercial scale at that. These methods may give us glycerol some day, too, but as for the glycerides with the complex fatty acids the work is already done for us by the sun in the air. There is no reason to be satisfied with things as they are, but there is every reason to be appreciative, whenever we can. That is the cheerful philosophy of research.

A Program for Harmony

THE past two weeks have been eventful in developing plans for harmonious relations between employer and employee and fostering the spirit of the square deal in industry. As reported in detail on another page the War Labor Conference Board, appointed last January at the instance of Secretary of Labor Wilson, has recommended the creaton of a National War Labor Board to settle by mediation and conciliation controversies arising between employers and employees in fields of production necessary for the effective conduct of the war. By proclamation of the President the National War Labor Board has since been appointed, and all interested parties are urged by him to use the means thus provided for the adjustment of industrial disputes.

Undoubtedly quickened by a sense of national peril, and realizing the necessity of unity in purpose and action, representatives of the two great groups comprising our industrial life have sought and agreed upon a basis for understanding during the war. Accepted

in principle by recognized leaders, there remains the more important problem of securing the active approval and sincere co-operation of the interested parties when occasion arises to test their professions. We have confidence that, in the main, the machinery provided in the Board will be effective and that it will not only contribute to industrial peace and harmony during the war but prove a large factor in all future relations between industry and workers. Primarily a fruit of war, the plan should be found effective as an agency for peace.

We may, however, regard one thing as certain. Public opinion is not going to be lenient with either party to the agreement who may violate its letter or spirit. The plan and purpose of the movement are sufficiently well defined to make it possible to place responsibility for broken pledges, and the public memory is likely to be more retentive than usual when it comes to remembering those who deliberately or tacitly impede the progress of the war by strikes or lockouts. Conciliation and mediation are the order of the day.

Another straw indicating the direction of the industrial wind, is the announcement of the plan for industrial representation of the employees in the Standard Oil Co. of New Jersey. Workers elected for the purpose by their fellows met and dined with high executives—captains of labor with captains of industry, as one engineer has put it—and plans of mutual interest were talked about and launched. Considering the success which a similar plan has met in the Colorado Fuel and Iron Co., controlled by the same interests, the New Jersey company may justly anticipate harmonious relations with its men.

The Steel Corporation

THE annual report of the United States Steel Corporation is issued for 1917 in its usual comprehensive form. The corporation's production of pig iron was 15,652,928 tons while the production of ingots was 20,285,061 tons. In both items there were decreases from 1916 to 1917, while the production by independents increased. The corporation's pig-iron production decreased about 2,000,000 tons, while the production in the industry as a whole decreased only 800,000 tons, showing that the independent production increased 1,200,000 tons while the corporation production decreased 2,000,000 tons. This divergence was due to the shortage of coke, which was experienced with particular severity by the Steel Corporation. No coke ovens were operated at capacity in 1917, and as the independents has made greater additions to capacity than had the corporation they had an advantage. The corporation resolutely refused to buy coke in the market, when the market was already crowded with buyers.

The above is the statistical explanation, the commercial explanation involving certain important details. The corporation had planned for larger coke-making capacity, but the difficulty of maintaining construction schedules was too great even for the Steel Corporation. An addition of 140 ovens has recently been completed at Gary, and there are now nearing completion, scheduled for at least partial operation by July 1, 640 ovens at Clairton, 208 at Lorain and 180 at Cleveland, making a total of 1,168 ovens, which are good for about 5,000,000 net tons of coke a year.

When the complete statistics of the American Iron and Steel Institute are compiled for 1917 they will show the coke consumption per ton of pig iron of all the blast furnaces, and beyond doubt an enormous waste of coke will be shown, caused by intermittent supplies and resultant bankings or slow operation. Even in the case of the Steel Corporation, which has large furnace groups and can manipulate its coke supplies to particular advantage—all its coke for use beyond Pittsburgh being consigned to the Conway yard for later routing—the coke consumption appears to have increased from 2,145 pounds in 1916 to 2,230 pounds in 1917.

An evidence of the effect of successive wage advances in the steel industry is furnished by the data given in the Corporation's report. There were three 10 per cent wage advances in 1916 and two 10 per cent advances in 1917. In 1913 the average salary or wage per day of all employees except general administrative and selling force was $2.85 a day. In 1917 the item had risen to $4.10, the 10 per cent wage advance of May 1 having operated for seven months and that of October 1 for only three months, while this month a 15 per cent advance goes into effect. From this it may be estimated that wages to be paid in future will average about 85 per cent above the average of 1913, the year before the war. Those wages were 50 to 60 per cent higher than wages obtaining in 1898. It is not only interesting, but important from a sociological and economic viewpoint, to note that in the latest wage advances the Steel Corporation has been the leader not only in form but actually in substance. The independents would not have initiated a wage advance this month, and some of them have criticized the advance which becomes general through the Steel Corporation's initiative.

The earnings the Steel Corporation reports for 1917 are $295,869,292, after paying interest on bonds of subsidiary companies, but before making allowance for bond sinking funds, depreciation, corporation bond interest, etc. This compares with $33,574,178 in 1916, the record year. This is the item that interests the shareholders, but the iron and steel manufacturing industry is interested in the total profits, before deduction of the Federal war taxes, as those are the earnings the mills and furnaces really made. It may be an incident of war that there was so large a margin between cost and selling price, but it is also an incident of war that the war taxes are levied. In the Corporation report as usually made all the taxes paid are stated in a lump sum, including municipal, county, state, etc. For 1916 this lump sum was $26,599,721. In the 1917 report the Federal taxes for 1916 are mentioned separately as having been $9,692,009, while for 1917 they were $231,465,435. This sum may be changed somewhat when adjustments are made with the Treasury Department. Comparison of the earning power of the plants may be made by adding Federal taxes to the reported earnings, this addition showing total profits of $343,266,787 for 1916 and $528,757,615 for 1917. These amounts are strictly comparable, being for each year the profits less all taxes but Federal, and less subsidiary company bond interest. The sums are subject to Federal taxes, bond sinking fund allowances, depreciation and similar items.

Readers' Views and Comments

Fats and Fatty Acids from Petroleum

To the Editor of Metallurgical & Chemical Engineering

SIR:—I believe the recent article by Dr. Gustave Egloff in METALLURGICAL & CHEMICAL ENGINEERING on the Snythesis of Fatty Acids from Petroleum merits some comment. To any one who has not had any experience in the synthesis or attempted synthesis of fatty acids and other derivatives from petroleum hydrocarbons, Dr. Egloff's article is somewhat misleading in its rather superlative optimism. There certainly is nothing in any work thus far published which would, by any stretch of imagination, warrant the statement that Germany may be feeding her population with synthetic fats made from petroleum.

The excellence of some of Dr. Egloff's previous articles might perhaps give the weight of authority to his statements on the fatty acid question, and I therefore feel that it should be pointed out that many of the claims made by authors quoted by Dr. Egloff are very far from good Anglo-Saxon truth. Perhaps the most prominent and most curious reference cited by Dr. Egloff is the work of Zelinsky. Zelinsky claims to have made fatty acids from petroleum hydrocarbons by preparing the Grignard magnesium complex of certain halogen derivatives of petroleum oils and reacting upon this with carbon dioxide. It is no reflection upon Dr. Egloff that he should have taken Zelinsky's work at its face value, but I suggest that any one interested may readily convince himself of the pure nonsense of commercial synthesis by this route by merely repeating, or attempting to repeat, Zelinsky's work. He will find that the yields are vanishingly small. The reasons for this are several, principal among which are the following:

1. The formation of the magnesium complex is exceedingly slow with derivatives containing more than eight or ten carbon atoms.

2. It is well known that the higher magnesium alkyl halides readily react with a second molecule of the original alkyl halide to give a hydrocarbon and magnesium halide. For example,

$$C_7H_{15}MgBr + C_7H_{15}Br \longrightarrow C_{14}H_{30} + MgBr_2$$

3. The halogen derivatives of petroleum hydrocarbons of ten to twenty or more carbon atoms are unstable and slowly break down on standing at room temperature to give free halogen acids and hydrocarbons which appear to be mainly saturated ring compounds. This behavior has not been published in any detail and I can cite no authority other than my own experience.

4. Stadnikoff in a series of comparatively recent papers showed that the alkyl magnesium halide and ether complex breaks down in a variety of ways. For example, Stadnikoff showed that a complex made from magnesium propyl iodide, carbon dioxide, and benzhydrylbutyl ether yielded a mixture of several hydrocarbons, free carbon dioxide and mixed ethers, only a trace of acid being obtained. He therefore states that the evidence gathered from a series of such studies points to the Grignard constitution rather than that of Baeyer, and suggests that the constitution of the compounds formed by passing in carbon dioxide is of the following type:

$$(C_6H_5)_2CH \atop C_4H_9 > O < \begin{matrix} C_3H_7 \\ CO_2MgBr \end{matrix}$$

There are obviously many other lines of attack, but I wish merely to point out that the methods so far disclosed are of practically no value for the purpose of making fatty acids from petroleum, even for the purposes of laboratory research, let alone commercial synthesis. For example, it is known that fusion of the higher alcohols with caustic potash yields free hydrogen and fatty acids, but only the higher primary alcohols give good yields. The secondary alcohols are very slightly oxidized under these conditions and yield mostly condensation products. The higher tertiary alcohols break down, giving acids of less number of carbon atoms. Also it has been shown that the alcoholates of the higher alcohols react with carbon monoxide under high pressures, but the principal products formed are esters of formic acid and not the higher fatty acids. The known methods for preparing alcohols direct from petroleum olefines yield only secondary and tertiary alcohols. Also no methods for adding halogens or halogen acids to the saturated or unsaturated hydrocarbons are known which give high yields of primary derivatives.

It is true that numerous methods have been proposed for oxidizing saturated and unsaturated hydrocarbons by air in the presence of various other substances and a great many wet methods have been tried, but the sum total of the results thus attained may be briefly summarized with the statement that in general the results are carbon dioxide, water, resinous or asphaltic material, and traces of the simple fatty acids such as acetic, propionic, butyric acids, etc., which usually have not been obtained in quantities sufficient for positive identification.

It cannot be too strongly emphasized that the chemistry of the aliphatic hydrocarbons is practically limited to methane, ethane, propane, butane and pentane and their derivatives. We then skip to a large island of knowledge which includes the chemistry of the terpenes and the reason for the rich development of this latter field is doubtless the ready availability of raw materials found in natural products—the essential oils. The books usually discuss the chemistry of the simple compounds, such as ethyl alcohol, ethyl bromide, ethyl cyanide, ethyl amine, butyric acid, fusel oil, etc., and then stop, usually with the added statement that the reactions presented for these simple derivatives are type reactions which hold good through the rest of the series. It would require more space even to indicate that this is not so than would be warranted in this brief note. Personally I believe that reactions which do not give yields of more than 2 or 3 per cent of the theory should *not* be inflicted upon the unsuspecting student as type reactions.

Our chemistry of the aliphatic series is decidedly spotty. We have a well rounded terpene chemistry,

a beautiful sugar chemistry, a complex chemistry of the fatty acids, and well perfected industrial methods, etc., but thus far the chemistry of the petroleum hydrocarbons brings up the tail end of the procession. Curiously enough the great bulk of the hydrocarbon chemistry which will go far in serving as a basis of exact chemical knowledge of petroleum has been done in Russia, although our own country has been blessed, as no other continent, with its rich petroleum resources. Personally I share Dr. Egloff's optimism to the point of believing that the commercial synthesis of fatty acids from petroleum *may* some day be accomplished, but not by the methods of synthesis now known and not until we have built up a much more extensive and quantitative knowledge of the behavior of hydrocarbons, such as constitute petroleum oils.

BENJAMIN T. BROOKS.

Flushing, N. Y.

* * *

To the Editor of Metallurgical & Chemical Engineering

SIR:—I am so much impressed with the value of the information conveyed in the paper entitled "Fats and Fatty Acids from Petroleum," printed in your issue of March 15, that I cannot refrain from expressing my appreciation and my hope that the authors will, before long, be able to present the results of their further work along the lines indicated in a later paper.

While I am not sufficiently well versed in the intricate combinations of carbon and hydrogen molecules to follow intelligently all the reactions involved and given in this new line of research, I have long been impressed with a belief, amounting to conviction, that, sooner or later, the problem of transforming and converting petroleum hydrocarbons into fats and fatty acids would be solved. The earliest patents mentioned by the authors for methods of this nature date back to 1912, but doubtless long before that time the subject had occupied the minds of chemists, for the prize is a most tempting one.

In a brief paper which I had the honor of presenting before the American Society for Testing Materials at its convention in June, 1911, on "A Novel Method of Detecting Mineral Oil and Resin Oil in Other Oils" (see Vol. XI, 1911), I said:

"Chemists will, I believe, eventually solve the problem that has hitherto baffled all their endeavors, of oxidizing hydrocarbon or mineral oils and of rendering them saponifiable. The monetary value of such a discovery is incalculable and the solver of the riddle would at once rank among great discoverers."

The authors italicize this remarkable statement: "*It is not improbable that Germany to-day is supplying a large part of her fats from synthetic production.*" If this be true, it becomes a matter of prime importance for our chemists to find a commercial process for the synthetic production of fats and fatty acids from hydrocarbons present in petroleum which the authors plainly indicate has already been, in a measure, successful, for they say in conclusion: "Fats and fatty acids from petroleum is more than an empty phrase."

I shall look for further information from them and I contribute this note with the view of calling the attention of your readers to the importance of their article.

ALEXANDER E. OUTERBRIDGE, JR.

Philadelphia, Pa.

Ammonia, Refrigeration and Munitions

To the Editor of Metallurgical & Chemical Engineering

SIR:—I was much interested in the article entitled "Ammonia, Refrigeration and Munitions," on page 277 of the March 15 issue of your journal.

Ever since this discussion of shortage of ammonia and the cutting down of its use by refrigeration plants came up, I have wondered that nothing appeared in the literature with reference to the substitution of liquid sulphur dioxide for the ammonia, and for some weeks I have been on the point of addressing you on this subject.

For quite a number of years sulphur dioxide has been used successfully in Europe for this purpose. It has many other advantages over ammonia, besides its much lower working pressure. I think it is from lack of correct knowledge, more than from any disadvantage inherent in this material, that it has not been used more for this purpose in this country.

I must take exception to the statement in your article that "SO_2 does not behave well in iron," unless that statement be qualified. It is true that liquid sulphur dioxide that is not pure and dry does attack iron, but it is also true that liquid sulphur dioxide which *is* pure and dry does *not* attack iron. At least one company in this country is making small refrigeration machines which are much more delicate than large commercial installations, using iron entirely for the cylinder and piston of the compressor, and, I believe, in all other places with which the gas comes in contact. When the gas used in these machines is sufficiently pure and dry they have no trouble with corrosion.

It is by no means as simple a process as most chemists would think, not having concrete experience with the matter, to separate water from, and dry perfectly, sulphur dioxide, but with properly designed apparatus, properly handled, this can be done with ease and certainty. The writer has made liquid sulphur dioxide on a large scale that has satisfied the most exacting requirements along this line.

It is perfectly true that but little of the liquid sulphur dioxide manufactured in this country, at least until recently, has been pure and dry; a number of the plants with which the writer is familiar for making this material have had installations for drying that were really laughable in their absurdity. One manufacturer passed his gas first up through a tower filled with packing, down which flowed sulphuric acid, *and then through a tower filled with calcium chloride to catch any sulphuric acid sprayed over from the sulphuric acid tower.* After this careful (?) drying it was stored in a gasometer *over water*, before being compressed and liquefied. This is hardly more absurd than other installations I have seen. Is it strange, then, that much of the sulphur dioxide on the market is not anhydrous?

Interest in the manufacture of liquid sulphur dioxide is increasing in this country, new plants are being erected and old ones remodeled. A tank car of special design has been proposed in which to ship the liquid, to do away largely with the excessive cost of transportation of the heavy containers usually used in shipping this and other compressed gases. Inasmuch as the pressure over liquid sulphur dioxide at ordinary tem-

peratures is so much less than that of most other liquefied gases, the use of such a tank car is possible. I think we can look for a large increase in the use of sulphur dioxide in the near future. While it is true that to the uninitiated there are many odd and unexpected troubles, yet to one with the necessary experience its manufacture is simple and without complication. It can be made readily from much of the sulphur gases now forming a nuisance in many communities. It could be used to great advantage in many places where sulphur is now burned to get the dioxide and no doubt in many places where sulphites are now used. With the increase in the amount manufactured, we can look for prices to drop to a point where its greatly extended use will be possible.

STEPHEN R. MOREY.

Yonkers, N. Y.

* * *

To the Editor of Metallurgical & Chemical Engineering

SIR:—In your issue of March 15 I note an article entitled "Ammonia, Refrigeration and Munitions."

In this article you state that sulphur dioxide cannot be used in ammonia compression systems. That "the pump and refrigeration pipes must be made of brass or copper for obvious reasons. SO_2 does not behave well in iron * * * ."

If you will investigate this subject further, I think you will find that you are in error in this statement. Sulphur dioxide in our experience, which has extended over a period of about seventeen years, performs just as well in iron and steel systems as in copper or brass; the latter, however, have an advantage in the matter of heat conductivity. If the sulphur dioxide is pure and reasonably free from moisture, and the proper lubricant supplied, there would be no difficulty in substituting it in ammonia systems. It is essential, however, that the ammonia systems be cleaned of ammonia and oil before introducing the sulphur dioxide.

The capacity for a given displacement, of course, would be considerably reduced, but in many cases refrigerating machines could be speeded up so that the plants could be operated at from 60 to 70 per cent of their normal rating.

In many cases machines are operated only a part of each 24 hours. By increasing the number of hours of daily operation, sulphur dioxide could be successfully substituted for ammonia, and still maintain full service in many existing refrigerating systems.

E. T. WILLIAMS.

Electrical Refrigerating Co.,
New York City

* * *

The Food Administration at Washington, in urging the conservation of ammonia, has very properly taken the position that the only way to save it is to save it. It would not have been good policy to suggest the substitution of SO_2 so long as there is any doubt on the subject. The opinion was also expressed that the substitution of SO_2 for NH_3 cannot be made successfully in the great quantity of refrigeration apparatus installed throughout the country, *as things are.* The same opinion was vigorously asserted by certain leading refrigeration engineers whom we consulted in regard to the matter. And it was a leading authority who insisted to us that in the long run sulphur dioxide refrigeration apparatus should not be constructed of iron. Our statement that "SO_2 does not behave well in iron" is open to the criticism that we should have said "moist SO_2." We took the moisture for granted because it is apt to be there.

But the problem involved is of far more importance than the correctness of our statements. There is prejudice as well as the fruits of research to be found in the art of refrigeration, and if prejudice stands in the way of progress we should try to remove it. The immediate problem is not to refrigerate with "properly designed apparatus, properly handled," but with the installations that are already built and duly set under all the eggs and fish. The drive is on, and all the ammonia there is—and then some more—is needed *now.* Let us admit that SO_2 may be suitably dried. Is it practicable to take a going concern now using ammonia, clean it speedily and effectively and shift over to sulphur dioxide without serious hazard of loss of stored merchandise or corrosion of the apparatus? Is it possible to test out such a change, using the same compressors, in a commercial plant of familiar design and thus prove that the substitution may be made generally? It would be a great boon, for it would release vast quantities of ammonia that are needed for munitions, provided it may be done now—right away. It would have to be done in existing apparatus without serious interruption of business.

If any of our correspondents has made the test and has the facts at hand, or is prepared to make the test to bring out the facts and prove that the change is practicable, our columns are open for him to tell the tale of it. We should be very glad to learn that in holding that the change cannot be made under existing circumstances, we were wrong rather than right. We are intensely interested in getting more ammonia for munitions and not at all vain about our own opinions.

EDITOR.

Sulphur Dioxide Method for Determining Copper Minerals in Partly Oxidized Ores

To the Editor of Metallurgical & Chemical Engineering

SIR:—Allow me to call your attention to an error in the article entitled "Sulphur Dioxide Method for Determining Copper Minerals in Partly Oxidized Ores," which appeared in your issue of February 15. Page 205, lines 26 to 29, inclusive, should read as follows:

"In general, when the solution to be standardized varies in strength from 1 to 3 per cent sulphur dioxide, add 1 cc. of this solution to 20 cc. of standard iodine solution. When the strength of the sulphur dioxide solution is appreciably below one per cent, add a larger quantity of this solution." The mixture is then treated * * *

This correction is essential to an understanding of the method presented.

CHARLES E. VAN BARNEVELD.

Tucson, Ariz.

Coming Meetings and Events

American Electrochemical Society, spring meeting, Southern trip, week of April 28.

American Society of Mechanical Engineers, Worcester, Mass., June 4-7.

Western Metallurgical and Chemical Field

Anaconda Company to Produce Ferromanganese

THE Anaconda Copper Mining Company will start immediately upon the construction of five electric furnaces of 4000 kw. capacity each for the production of ferromanganese, according to a statement by C. F. KELLEY, vice-president of the company. These furnaces will be installed in the present smelter building at Great Falls, which has ample room under the converter craneway. Consequently, with an excellent building and overhead cranes, a well-developed system for handling the materials and all the other auxiliaries at hand, the actual installation of the simple shaft furnaces will be a matter of a short time and dependent largely upon the procurement and delivery of the necessary transformers, electrodes and their automatic regulators. The necessary electric power, to the extent of about 20,000 kw., is already developed by the Montana Power Company, and can be delivered over present lines of large capacity connecting the Great Falls smelter to the hydroelectric plants farther down the Missouri River. Under such favorable conditions, it is hoped that the necessary special equipment may be procured by special arrangement, and the furnaces may be running by the middle of the summer.

The ores for their operation will come in large part from the Butte mines of the Anaconda Copper Mining Company, several of which have manganese-bearing oxides in their upper levels. In fact, a quantity of manganese ore has been collected from various shallow prospects and old dumps by ore-pickers and marketed through a local mill. In addition to these supplies, which will be fully exploited, the neighboring Phillipsburg district has been developed into one of the most important manganese producers in the United States, now shipping about 500 tons of 45 per cent ore daily, any necessary part of which may be diverted to the new furnaces. The plant is expected to produce 100 tons of ferromanganese per day.

Potassium Sulphate from Cement Dust

A rather unique and successful plant for the recovery of potassium from cement-kiln dust has been installed at the Southwestern Portland Cement Company by MR. J. G. DEAN, their chemical engineer. The cement plant is operating under the wet process, and the stack gases average about 40 per cent water vapor at a temperature of 600 deg. Fahr. They are first conducted through a dust chamber 200 ft. long placed underneath the kiln, where six or seven tons per day of the heavier dust particles are deposited. The gas then passes through a concrete flue to a fan, which delivers it to a spray chamber where a water spray brings down most of the remaining dust. The gases, heavily laden with the water vapor, are then sent to a condenser, and on being cooled the moisture begins to condense on any dust particles which may remain, and, of course, if these particles happen to contain potash, it is dissolved and washed out with the condensate.

This condensate is pumped into suitable tanks and is used as the condensing medium on the other side of the condenser tubes. The difference in temperature necessary is maintained by a vacuum of 24 in. (with a barometer of 27 in.), so that the installation, which, by the way, is entirely of reinforced concrete, is in effect a combined condenser and evaporator. This brine or condensate is eventually evaporated to saturation, when the potash salts crystallize out as sulphates.

It will be seen that this installation has considerably more evaporating than condensing capacity. In other words, they are condensing about 150 lb. of water per minute, and evaporating about 300 lb. per minute, which permits them to do any necessary extra scrubbing.

The chemistry of the process is very interesting. It has been found that by regulating the burning so as to maintain a slightly reducing condition in the kiln, the condensate holds in solution the following ions: K, Na, SO_4, CO_3 and S_2O_3. Some of the carbonates are changed to bicarbonates, and these serve to eliminate the sulphides. Since there is not quite enough of the sulphate ion to unite with all of the potassium ion, this deficiency is supplied by running the solutions through a bed of gypsum. This removes the carbonate ion and supplies the necessary sulphate and makes it possible to crystallize a very pure potassium sulphate, and at the same time produce a sodium thiosulphate of value.

There is no particular labor expense attached to the installation at the Southwestern Portland Cement Company other than the wages of one or two attendants necessary to take care of the collecting and refining apparatus. In other words, the flue dust collected will pay all the expense of collection and purifying, so that the potash is really so much profit.

Potassium Sulphate from Alunite at Marysvale, Utah

The rebuilt plant of the Mineral Products Corporation at Alunite, near Marysville, Utah, has started operations and is producing twenty tons of 97 to 98 per cent potassium sulphate per day. The original plant was constructed by Westinghouse, Church, Kerr of New York, and was admittedly of experimental nature. It was highly successful, however, and immediately after the fire of Oct. 25, 1917, a contract for reconstruction was placed with the Industrial Engineering Company of Salt Lake City. Current reports that the fire which destroyed the leaching, evaporating, storage and power buildings was of incendiary origin are incorrect, as the source was undoubtedly a spontaneous fire in the coal-pulverizing plant.

The general plan of the new works follows that of the old, with minor modifications found desirable by the early operations. Fortunately the evaporators themselves were damaged but slightly, and the crushing department and kiln rooms uninjured. Briefly, the process in use is as follows: The alunite, a moderately hard, brittle mineral (a hydrated double sulphate of potassium and aluminium) is first crushed to about 1-in. size and then roasted in a rotary kiln much like the familiar cement kiln, a brick-lined cylinder 7 ft. 6 in. in diameter and 135 ft. long, fired with pulverized coal. The calcined material is then leached with hot water in a closed tank at a temperature corresponding to 60 lb. steam pressure, which takes the K_2SO_4 into solution. The larger pieces of insoluble siliceous material are unaffected by this digestion, and are removed

from the liquor by merely screening. The solution is then filtered in a Kelly filter-press, which removes the fine solids—largely Al_2O_3 minus 300-mesh, together with a small percentage of silica and iron oxide. The clear filtrate is then evaporated in Swenson triple-effect evaporators, when the resulting crystals are centrifuged and sacked for shipment.

The company is planning to take up the matter of disposal of by-products as soon as the new plant attains its rated capacity of 30 tons of potassium sulphate per day. The alunite mined by the Mineral Products Corporation is contaminated with a relatively small amount of impurities. The coarse screenings, silica and aluminium silicates should therefore make excellent refractories, while the filter-cake, if it can be purified of the small amount of iron and silica it contains, should be converted into aluminium metal or aluminous abrasives.

Placer Platinum in California and Oregon

Chemists and metallurgists have long been interested in the high price of platinum which has all but prohibited purchases of new scientific equipment made of this element. Its absolute necessity as a munition is further emphasized by a war department order issued early in March requisitioning all crude and unworked platinum in the hands of importers, jobbers and wholesalers.

The platinum metals are found in quantities of economic importance at only a few places. The bulk of the world's production has heretofore been furnished by the placers of the Ural mountains, in Russia, but the production from this source is decreasing, while Colombia is becoming an increasingly large producer. Under normal conditions the United States requires about 165,000 oz. a year, while we produce only a few thousand ounces, and have met with increasing difficulties in importing sufficient supplies. The only considerable recent importation was a lot of about 21,000 oz. collected in Russia by Norman C. Stines, managing director of the Sissert Mining District Company, and brought to America in the baggage of a returning engineer, S. W. Draper.

The small American production, aside from that recovered from the refining of blister copper, is almost entirely recovered incidental to gold placer mining operations in California. At periods of about fourteen days the gravel contained in the sluices is cleaned up and the waste washed out with a hose stream, leaving behind a small pile of sand and amalgam. This material is again washed over a smaller riffled sluice containing traps for the "quick," and the resulting black sand containing the platinum, with some gold, osmium and iridium, is shipped to a refinery. Jas. W. Neill* estimated that a 3¾-ft. dredge mining about 68,000 cu. yd. per month was losing apparently 4.75 oz. of recoverable platinum per month, against a total caught and saved in the riffles of about 1.85 oz., and he installed a small Wilfley table to retreat the 20-mesh hutch product of jigs set below the sluices to catch tramp amalgam. It would be too much to expect the sixty-five million yards of gravel dug annually by the dredges in California to produce platinum at this average rate (1 oz. per 10,000 cu. yd.) since the output, 6500 oz. of platinum, would then far exceed the total of 710 oz. produced during 1916. Doubtless much more could be recovered by intelligent effort before the additional cost would overbalance the returns.

*Mining and Scientific Press, Dec. 8, 1917, page 828.

Smoke Purification at Anaconda

Shortly after operations at the Washoe Plant were started by the Anaconda Copper Mining Company some fifteen years ago, it was seen that the plan of having individual smokestacks for each department was causing considerable smoke damage to the surrounding country, and heavy expenditures were immediately undertaken to provide long flues connecting the various furnace buildings to a much wider hopper-bottomed flue acting as a dust chamber and leading up the hill to the "big stack" 30 ft. in diameter and 300 ft. high. In this way this pioneering organization showed their faith in that palliative which the most recent and painstaking research has shown to be the only known commercial method of disposal of dilute sulphur dioxide; that is to say, adequate dissemination in the upper atmospheric strata.

The continual increase of the amount of ore treated in this huge smelter has gradually overloaded even this flue system. Klepinger's studies, and the resulting flue system and stack at Great Falls, amply demonstrated the financial advantage of making adequate clearance of the solids, while additional pressure was brought to bear on the company by the final decree of their numerous and hard-fought "smoke suits." In the meantime, Dr. Cottrell's system for smoke clearance had been closely investigated, both in large and small-scale tests, and it was finally determined to build such a treater capable of handling the entire gases of the smelter (some 2,000,000 cu. ft. per minute). This program calls for an initial expenditure of about $2,500,000 and is well under way at the present time; wagon and railroads up the hill to the site are completed, and the excavation and foundation work is finished.

The new treater and stack will be located on a high ridge leading to the south of the present 300-ft. stack. The gases will be drawn from the top and end of the old flue where it branches out to either side before entering the old stack, through a double flue alongside a treater plant located beyond both chimneys, and thence back into the new chimney through flues placed between the treater structures. The chimney will be constructed of locally made brick, and will be 60 ft. inside diameter at the top and 525 ft. high, and is thought to be the most massive in existence, comparing in bulk with the Washington monument.

The treater plant itself will originally contain twenty sections, in two parallel lines of ten each, and will use "box-type" passageways, consisting of corrugated iron partitions for dust collecting, 12 in. apart, with a series of electrified chains suspended between 5-in. centers. The voltage used will be 75,000. Sufficient ground area has been prepared for doubling the treater construction, should it prove desirable in the future.

The recovered dust will be smelted nearby in a large modern reverberatory furnace, producing a matte containing the metallic values. The gas from this furnace will pass through a hot treater, recovering the true dust it contains for return to the furnace, and a cold treater, will precipitate the condensed metalloids, largely As_2O_3.

Important Developments Relating to Labor and Capital

National War Labor Board Recommended by Representatives of Employers and Emlpoyees. Standard Oil Co. of New Jersey Introduces Industrial Democracy. Mining Engineers Discuss Labor Problems

THE War Labor Conference Board composed of five representatives each of employers and employees, and two representatives of the public, appointed some time ago at the suggestion of Secretary of Labor Wilson to aid in the formation of a national labor program for the period of the war, has made its report and recommendations as follows:

That there be created for the period of the war a National War Labor Board with the following functions and powers:

1. To bring about a settlement by mediation and conciliation of every controversy arising between employers and workers in the field of production necessary for the effective conduct of the war.
2. To do the same thing in similar controversies in other fields of national activity, delays and obstructions which may, in the opinion of the National Board, affect detrimentally such production.
3. To provide such machinery by direct appointment, or otherwise, for selection of committees or boards to sit in various parts of the country where controversies arise, to secure settlement by local mediation and conciliation.
4. To summon the parties to the controversy for hearing and action by the National Board in case of failure to secure settlement by local mediation and conciliation.

In case the National Board is unable to effect a voluntary settlement or agree upon a decision, an umpire shall be chosen by unanimous vote or drawn by lot from a list of ten persons nominated by the President of the United States. No cognizance will be taken of a controversy between employer and workers in any field of industrial or other activity where there is by agreement or federal law a means of settlement which has not been invoked.

In their capacities as mediator or conciliator the Board or the umpire shall be governed by the following principles:

No Strikes or Lockouts During the War

The right of workers to organize in trade unions and to bargain collectively, and the equal right of employers to organize in associations and to bargain collectively, is recognized and affirmed, and shall not be denied, abridged or interfered with by either party. Employees should not be discharged for membership in trade unions, nor should they use coercive measures to induce persons to join their organizations, nor to induce employers to bargain or deal with them.

Present conditions as to union, non-union or open shops are to continue. Established safe-guards and regulations for health and safety shall not be relaxed. Women employed on work ordinarily done by men must be allowed equal pay for equal work. The basic eight-hour day is recognized as applying in all cases in which existing law requires it. In all other cases the hours of labor shall be settled with due regard to governmental necessities and the welfare of the workers.

Maximum Production to be Maintained

The maximum production of all war industries should be maintained, and methods of work and operation on the part of employers or workers which operate to delay or limit production, or which have a tendency to artificially increase the cost thereof, should be discouraged.

For the purpose of mobilizing the labor supply with a view to its rapid and effective distribution, a permanent list of the number of skilled and other workers available in different parts of the nation shall be kept on file by the Department of Labor, the information to be constantly furnished by the trade unions; by state employment bureaus and federal agencies of like character; by the managers and operators of industrial establishments throughout the country.

The recommendations recognize the right of all workers, including common laborers, to a living wage. In fixing wages, hours and conditions of labor, regard should always be had to the labor standards, wage scales and other conditions prevailing in the localities affected. Minimum rates of pay shall be established which will insure the subsistence of the worker and his family in health and reasonable comfort.

Standard Oil Co. Launches Industrial Plan

On April 1 a group of the officials of the Standard Oil Co. of New Jersey and some seventy delegates elected by the workmen in the New Jersey plants met at dinner at the company's offices in New York. The announced purpose was to bring employer and employee together for the free discussion of matters of mutual interest. It was definitely stated that there was not the slightest strain in the present or prospective relations between company and workmen, and that the idea of meeting together was to effect still closer relationship and insure continued harmony between the company and its employees.

The dinner marked the beginning of industrial representation among employees in the Standard Oil Co. A consequence of far reaching importance is the practical assurance of harmony in the organization during the war. Considering the importance of petroleum and its products it is highly desirable that there should be no disturbances in oil-producing concerns.

President Teagle announced an increase in wages effective April 1, averaging 10 per cent., applicable to all wage earners except first-class bricklayers and watchmen whose rates are increased 5 per cent, and lead burners whose rates were previously increased.

C. J. Hicks, executive assistant to the chairman of the board, explained certain plans which the company has for its employees, including a system of benefits and annuities. Arrangements are to be made whereby all

employees, after one year's service, without cost to themselves, shall be given an individual life insurance policy. One year's service carries a death benefit equal to three months' full pay; two years' service, five months' full pay, and so on progressively, until five years and over carries the equivalent of twelve months' full pay, with a minimum of $500, and a maximum of $2000.

Annuities are planned on the basis of a regular allowance of 2 per cent. of salary for each year of service for all employees at the age of 65 years, after twenty years' service, with a minimum of $300 per annum and a maximum of 75 per cent. of salary. Special provisions are made for employees less than 65 years of age, retired after twenty and twenty-five years of service.

Regulations were proposed governing the discharge of employees, and a list of offenses was agreed upon for which alone a man shall be subjected to summary dismissal. For other offenses the employee is to have due warning before dismissal. In case of possible injustice, the privilege of higher appeal is reserved to the worker.

Plans are under way for improvements in sanitation and housing at the company's plants. These were explained in detail by Mr. Hicks, who announced that Mr. Rockefeller had subscribed $50,000 to the Bayonne Housing Corporation and had donated that stock to the new Bayonne Y. M. C. A. toward the construction of which he had also given $100,000.

Mining Engineers Discuss Labor Problem

At the April meeting of the New York Section of the American Institute of Mining Engineers the evening was devoted wholly to a discussion of the labor problem. Following is a report of the proceedings.

Mr. Sidney J. Jennings, vice-president of the United States Smelting, Refining & Mining Company, traced the origin of the company from its inception to the present time. He found that the fundamental idea of the company and of the issuance of shares was one of co-operation. He then analyzed the present relation of the company to industry and said that if the company was not fulfilling its proper function it might have to be abolished. He found three dangers besetting the proper conduct of the modern company. First, the capitalist becomes divorced from a sense of personal responsibility in the operation of the business; second, the actual manager or management may have considerable power without having any capital interest in the concern; and third, the laborer or worker feels that he is only a cog in the big wheel.

Mr. Jennings suggested the following methods for overcoming the feeling which the laborer has that he is only a cog in the machine. He cited the fact that the United States Steel Corporation offers actual partnership through the purchase of shares in the corporation. Second, he thought that profit-sharing above a fair return was one of the best means of making the company a true co-operative agent. Third, he felt that a central employment manager was almost essential to maintaining harmonious relations between the company and the workers. A good employment manager can be responsible for either the good-will or the ill-will of employees which in turn means success or failure of the institution.

Mr. Walter Douglas of the Phelps, Dodge Corporation operating copper mines in Arizona, said that it was becoming increasingly difficult to get the viewpoint of the wage earners due to the increasing numbers of men employed by individual companies. He contrasted former conditions when the employer, manager or shift-boss had so few working under him that he knew them all personally and could get their viewpoints very readily, with present conditions where concerns have thousands and tens of thousands of men in their employ without the possibility of knowing them all personally or getting their point of view. He thought that some substitute must be found to bring about the close personal touch which formerly existed in the small companies. He spoke of the necessity of getting specialists to analyze labor problems for companies and thought that engineers should be the first to seek the aid of such specialists. He thought that the manager of a concern is not suited to this particular kind of work and yet he is the one who most frequently tries to solve the problem himself. Mr. Douglas believed that the solution will be found in some intermediary between the employer and the employee, and stated that the labor union has not yet filled this gap. He was quite certain that the big problem in the labor situation is not one of wages or hospital dues or any such item, but rather the thousands of little things that the company knows nothing about until a crisis comes. It would be the duty of an intermediary to know what these things are and to correct evils before they develop into crises. The type of man best able to deal with labor would be one who has been a leader of labor himself, and he cited Secretary Wilson and Mr. Mitchell as types who would be good intermediaries for large concerns. Speaking for the Phelps, Dodge Corporation he said that they had an employment agent at the Copper Queen mine whose duty it was to employ, transfer and dismiss all workers. The foreman of any department could not dismiss a man but was obliged to inform the employment manager that the man was not suitable for that particular work, whereupon the employment manager would transfer him to some more suitable place. The company has a pension system for those who have worked for the company for fifteen years. The pension is 2 per cent. of the salary for the number of years worked, and has a maximum of $1000 per annum. The company operates a benefit association to which 80 per cent of the employees belong. The company contributes about an equal amount with the employees. This past year an experiment was made in offering a flat service bonus of $100 to every man who had worked for the company one year. This was offered without regard to his position or salary and was a straight premium for sticking to the job.

Targets of Labor Agitators

Mr. Douglas said that the points on which the labor agitators had played most strongly were the company store and the hospital. He showed that the company store reduces the cost of living and that only recently 90 per cent. of the employees at Ray, Miami and Globe had petitioned his organization to establish company stores at those places. He felt that the hospital is a different problem and that if the company does not run it, it will not be run right and the men will not receive adequate attention. The charge for this service is nom-

inal and yet the agitators always find a good deal of fault with both the company store and the hospital in spite of the fact that both institutions are for the good of the employees. Mr. Douglas then touched briefly on the work of the president's mediation committee which settled the recent fight in Arizona. This report has been published by the U. S. Department of Labor.

Mr. J. Parke Channing said that while the United States had been efficient as far as methods and processes are concerned, we have not been efficient in the utilization of our man power. He cited the change which has taken place in England since the beginning of the war and showed that England had become a socialistic community which was highly efficient, with the government doing almost everything. He said that the English laborers were not going to be content to return to the old order of things. He admitted that the problem in Great Britain was simpler than in the United States on account of the fact that practically all of England's laborers are English, while the United States has a mixture of unassimilated foreigners. He felt that if we are to carry the war to a successful conclusion and increase our efficiency after the war we must Americanize our foreigners and give them our own point of view. He then outlined the proposed program of the British labor party which has four principles or pillars, namely,

1. Universal enforcement of the national minimum.
2. The democratic control of industry.
3. The revolution in national finance.
4. The use of surplus wealth for the common good.

If these four demands are carried out, England will be a socialistic state. Mr. Channing did not presume to say how much this program could or should be carried out but cited it as showing the trend of thought in England.

The British workman has seen his wages increase and he is more than ever convinced that in the past he had not been getting his fair share of the products of his toil. Mr. Channing also believed that the workman was realizing that he had not done his proper share toward increasing the wealth of the country. Generally speaking the British workman has seen such good results obtained in the democratic control of industry during the war that he feels that such control should be just as efficient after the war. Mr. Channing distinguished between the English labor party and the Bolsheviki of Russia, saying that the former did not believe that the working class should manage the country; that the English labor realized the importance of brains and education and the necessity of these things in bringing the country to the highest state of development. He felt that a program similar to that in England was likely to come up in the United States and that we should be on our guard lest the pendulum swing too far, as it is likely to do if the employing class does not give more attention to the worker and see that his condition is improved. He felt that engineers were the best instruments for carrying out the necessary work. He spoke of the growing tendency to give engineering students some training in human engineering and cited such courses at Columbia University. In discussing trade unionism he said that Professor Hoxie's work on Trade Unionism in the United States would clarify anyone's ideas of that subject and suggested that the book be read by all engineers. He spoke very favorably of the work of the industrial department of the Y. M. C. A. in human engineering.

Success of Conciliation Board in Anthracite Field

Mr. Edwin Ludlow, vice-president of the Lehigh Coal & Navigation Company, agreed with Mr. Schwab that "labor is now in the saddle." He said that the time had come when we must have captains of labor as well as captains of industry and that both of these factors must get together if we are to have the best development of industry. He reviewed conditions in the anthracite fields of Pennsylvania beginning with the strikes some years ago which were settled by Mr. Roosevelt. He explained the nature of the commission which was established at the time and reviewed the document which that commission drew up and which has stood the strain of fifteen years of active application. The most important feature of the method of settling disputes was the establishment of a board of conciliation which was the final arbiter. Another important point was, that pending the adjudication of any disagreement there should be no suspension of work either by lockout or strike. Mr. Ludlow thought that we made a mistake if we do not encourage the better class of men to join the union so that those organizations will be directed by the best thought among the laborers.

Dr. E. E. Southard, a physician and one of the directors of the Psychopathic Hospital of Boston, spoke of the possible use of the psychologist in handling labor for large organizations. He felt that there was a reasonably good field already developed for this type of scientist in assisting large concerns to get the right men for the right jobs and to analyze a good many conditions which are purely psychological in their character.

Mr. R. J. Young of the Illinois Steel Company told what that organization had done in a very elaborate way toward taking care of its employees and trying to establish harmonious relations between the workers and the company. He laid considerable stress on the idea of an employment manager whose function it was to secure a desirable labor supply. He spoke of part ownership by employees and suggested that when a certain percentage of the total stock was owned by employees they should have representation on the Board of Directors of the company. With regard to pensions he raised the question as to whether the amount paid should be based on the wages of the man or on his ethical value to the company. He thought that basing a pension solely on the wages previously earned was not wholly a fair method. Mr. Young then outlined very briefly the numerous activities engaged in by the steel corporation in an effort to create good working conditions and establish harmonious relations between the company and the men. Among these efforts were medical supervision, dental clinics, shop sanitation, industrial canteen, domestic science instruction for the laborers' wives, proper illumination of shops and homes, fire prevention, proper ventilation, recreation for the workmen and their families, education for the children, housing and insurance. He laid considerable stress on the value of picking proper individuals for foremen because they represent the management to the men and hold very important positions in the organization.

The Solubility of Paraffins, Aromatics, Naphthenes and Olefins in Liquid Sulphur Dioxide

A Study of the Possible Utility of Liquid Sulphur Dioxide in Oil Refining and Analysis. Solubility of Pure Substances and Separation of Mixtures

BY ROBERT J. MOORE, J. C. MORRELL AND GUSTAV EGLOFF

IN THE analysis and refining of oils, the question of procedure has long been a vexed one. Methods for the determination and isolation of the various constituents of natural petroleums and artificial oil mixtures follow no general scheme and are of questionable accuracy. The well known sulphonation for olefins and nitration for aromatics have long been used as more or less approximate tests for the want of something better. Moreover with this method the unsaturated and aromatic hydrocarbons are lost, since their recovery from the acid sludge is difficult, and their physical properties therefore are based on calculation of the oil before and after treatment, giving questionable results. The present paper is a contribution to the analytical and refining methods on hydrocarbon oils based on their solubilities in liquid sulphur dioxide.

In 1892 Walden[1] used liquid sulphur dioxide as a solvent for many inorganic and organic substances, dissolving, among others, benzene, phenol, naphthalene, aniline and diphenylamine. This property of liquid sulphur dioxide to dissolve certain organic substances was used by Edeleanu[2] in the refining of crude petroleums. He found that "if a distillate is agitated with liquid sulphur dioxide at a low temperature the aromatic compounds are dissolved but the paraffins and naphthalenes are unaffected." With this as a basis he evolved the process bearing his name, which has been used to some extent in Italy and Germany. In his paper Endeleanu shows the efficacy of his process in refining many illuminating oils and compares results with the ordinary methods of refining. He finds also that liquid SO_2 has a marked effect in removing certain sulphur-bearing compounds along with the aromatics.

The admirable work of S. E. Browery[3] which has recently come to the authors' attention takes up the refining with liquid sulphur dioxide in more detail. Using Edeleanu's method at —12° C. Browery found that conditions applied to purifying lamp oil do not hold for lighter fractions. For example, at —12° C., the lamp-oil fraction from a Trinidad crude, treated three times with half its volume of sulphur dioxide gave highly satisfactory separation. On the other hand a light distillate (up to 150°C.) from the same crude yielded extracts containing about equal parts of aromatics and paraffins. By working at lower temperatures than —17° C. it was found possible to improve results up to a point at which satisfactory correction could be applied by means of specific gravity determinations. A series of extractions run on artificial mixtures containing about 15% aromatics and using temperatures to —35°C. (Obtained by evaporating liquid SO_2) showed fairly accurate results. The method was applied to the determination and recovery of toluene in crude oil from Trinidad Central. Browery states that "naphthenes are insoluble in SO_2 and are therefore left with the paraffins."

Rittman and Moore[4] in 1915 published a note on the liquid SO_2 method of separating aromatics from paraffins. Their results show fairly good separations for low percentages of aromatics but not on higher percentages. In their work which was merely a preliminary note on method, the burette was embedded in ice and salt mixture and its removal for volume reading took time and made temperature readings uncertain.

Scope of Present Work

The literature contained no work on the individual solubility in liquid sulphur dioxide of the various hydrocarbons. As this seemed essential to any comprehensive work the curves of various pure compounds were determined. The results on naphthenes were contrary to the statements of both Edeleanu and Browery and are discussed later. The solubility of the following dydrocarbons was determined: Pentane plus hexane, hexane, octane, nonane plus decane; washed gasolene, washed kerosene; benzene, toluene, xylenes, mesitylene; hexalene, caprylene; cyclohexane and naphthenes boiling within the following limits, 75°-155°, 155°-175°, 175°-185°. These solubilities were determined at temperatures of —10° C. and —18° C. A series of SO_2 treatments was then run on a number of synthetic mixtures and results tabulated.

Procedure

A modification of Edeleanu's apparatus was used as illustrated in Fig. 1. The oil to be treated was run into the graduated burette, then placed in the cooled alcohol bath and its volume read, the temperature of the bath being recorded on a toluene thermometer. A zinc tube embedded in a freezing mixture of ice, salt and calcium chloride served as the container for the alcohol bath, the outer container being well insulated with heavy felt. It was found that this apparatus could be kept at almost constant temperature over a range of 75 minutes for the lower temperature. The liquid SO_2 was run in from a tank through heavy-walled rubber pressure-tubing. The volume of SO_2 was read off as the increase in volume in the burette. A modification of this was used on mixtures. The SO_2 was first run out into a glass stop-cocked closed burette. This burette was then attached by means of heavy rubber tubing to the burette containing the oil and the volume of SO_2 used read off on the first burette. If separation into two layers occurred, both volumes were read. Burettes of various capacities were used depending on the volume of oil to be treated or the volume of SO_2

[1] Ber., 32,2862, 1899.
[2] Bull., A. I. M. E., 93,2313, 1914.
[3] Pet. Rev., 36,351,385,401, 1917.
[4] Met. & Chem. Eng., 13,713, 1915.

to be added. The separated layers were run off into different tubes and the SO_2 separated either by evaporation or by solution in dilute sodium hydroxide, after which the separated oils could be measured and their specific gravity and indices of refraction determined. The latter were measured with a Pulfrich refractometer. Specific gravities were taken with a Westphal balance where possible or with a 1-cc. pycnometer.

In several instances, where minute quantities of one or two drops were separated, a special method had to be devised for the accurate determination of such small quantities. The method finally adopted may prove useful to experimenters in determining this physical constant of minute quantities, one drop of the substance being sufficient for a number of measurements. The method employed was as follows: A two or three-inch piece of fine, thin-walled, capillary tubing is weighed on an accurate balance to the fourth decimal place. Then, held upright in a small pair of weighing forceps, the lower end is dipped in the drop of substance which immediately fills the entire tube due to capillarity. As soon as it is filled it is placed on the pan of the balance and weighed again, the increase giving the weight of the substance. The tube is then cleaned and its volume determined by weighing filled with water. The specific gravity is then calculated for the temperature at which the tube was filled. If the substance under examination is highly volatile, the capillary tube as soon as filled may be placed in a small glass-stoppered weighing bottle. This method was checked up by the Westphal balance on toluene, benzene, and alcohol and gave satisfactory results on volumes as low as 0.012 cc.

Hydrocarbons Used

The physical properties of the oils used are given in groups in Table I.

TABLE I. PARAFFINS

Name	B. P. °C.	Sp. Gr. (Westphal) 15.5° C.	(Pulfrich) Index	Treatment with Conc. H_2SO_4 and Conc. HNO_3
Petroleum Ether (Butane, Pentane and Hexane)	Below 50°	0 643	1.3629	No coloration
Pentane and Hexane	55–65°	0 650	1 3700	No coloration
Hexane	68 8°	0 655	1.3734	No coloration
Octane	125 4–125 6	0 706	1 3999	No coloration
Nonane and Decane	156–159	0 730	1 4174	No coloration
Gasolene *	50–175	0 721	1 4008	No coloratioo
Kerosene *	120–250 = 89%	0.779	1.4277	No coloration

Aromatics

Name	B.P. °C.	Sp. Gr. 15.5°C.	Index	Remarks
Benzene	80.2–80.4	0 880	1.5014	No coloration with 1 84 H_2SO_4
Toluene	109–110 2	0 870	1 4982	No coloration with 1 84 H_2SO_4
Xylene (p-xylene)	138	0 880	1 4961	No coloration with 1 84 H_2SO_4
Mesitylene	162 163 5	0 870	1.4991	No coloration with 1 84 H_2SO_4

Olefins

Name	B.P.	Sp. Gr.	Index	Remarks
Hexylene	68°	0.689	1 3994	Combined completlly with 1.84 H_2SO_4
Octylene	121–124	0.724	1.4145	Combined completely with 1 84 H_2SO_4

Naphthenes

Name M. P.	B.P.	Sp. Gr.	Index	Remarks
Cyclohexane, 6.4°	80–80 2	0 780	1.4255	No coloration with H_2SO_4 or HNO_3
Naphthenes	75–155	0 784	1.4267	
Naphthenes	155–175	0 799	1.4345	No coloration with H_2SO_4 or HNO_3
Naphthenes	175–185	0.809	1 4379	No coloration with H_2SO_4 or HNO_3

* The gasolene and kerosene were distilled from Pennsylvania crude, washed repeatedly with fuming sulphuric acid, neutralized with dilute sodium hydroxide, washed with water and dried over calcium chloride

The cyclohexane was a particularly pure specimen melting at 6.4°C. The sulphuric acid and nitration tests showed no trace of either olefins or aromatics, and the absence of paraffins was sufficiently proven by its specific gravity, index of refraction and sharp freezing point.

The higher boiling-point naphthenes used were distilled from naphthene-base oil distillates used in a previous research.[5] The following fractions were used: Boiling points 75°-155°, 155°-175° and 175°-185°. These were washed free from olefins and aromatics. The specific gravity and index of refraction of these fractions indicate their naphthenic nature. In Table II these values are compared with the physical properties of pure paraffins and pure naphthenes.

TABLE II.

Boiling Point Range °C.	Pure Paraffins *	Pure Naphthenes *	Oil Used
75–155	Sp. Gr. —0 712	0 778	0.784
	Index —1 411	1 429	1.4267
155–175	Sp. Gr. —0 730	0 798	0.799
	Index —1.413	1 44	1.4345
175–185	Sp. Gr. —0 745	0.803	0.809
	Index —1 4158	1 433	1.4379

* Values taken from Engler—Hofer, Das Erdol.

The paraffin and naphthene hydrocarbons are almost identical in their inactivity toward reagents, and therefore offer difficulty in distinguishing one from the other. But if we know that an oil is free from olefins

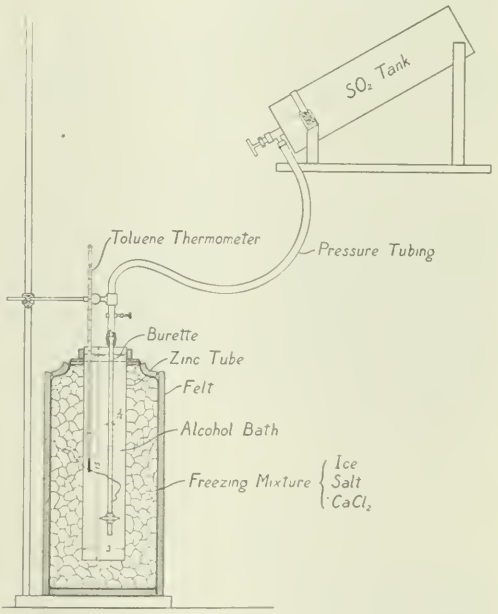


FIG. 1.

and aromatics, through sulphonation and nitration, specific gravities and refractive indices are sufficiently wide apart to distinguish pure naphthenes from pure paraffins. The above table shows that in each case the properties of the oil used closely approximated the values for the pure naphthenes, and were sufficiently higher than the value for paraffins to assure absence of the latter. The difference in their behavior with the liquid sulphur dioxide checked up their difference in chemical structure.

[5] Egloff and Moore, Met. & Chem. Eng., XV, 6, 1916.

Solubility of Aromatics in Liquid SO_2

The solubility of pure aromatic hydrocarbons in the liquid SO_2 is shown in Graph I. Two different percentages of liquid SO_2 were used, 33.3% and 66.7% and two temperatures —18°C. and —10°C. The four aromatics used, benzene, toluene, xylene and mesitylene were completely miscible in all cases. In using the benzene which freezes at 6°, the SO_2 was run into the kerosene at room temperature, shaken and then placed in the bath. With 33.3% SO_2 only a slight turbidity was visible due to a tendency of the benzene to freeze.

Solubility of Paraffins in Liquid SO_2

The insolubility of paraffin hydrocarbons is shown in Graph I. Pentane plus hexane, hexane, octane, nonane plus decane, gasolene and kerosene are shown to be insoluble at —18° and —10° and with varying proportions SO_2. With kerosene at —18°, from 33.3% to 98% SO_2 were used. The relative solubility of the liquid SO_2 in paraffins was determined ranging from an unmeasureable quantity at —18° to 1.8% at —10° for the low boiling-point members and increasing in solubility to 3.6% in the higher boiling kerosene oil. There was in no case an indication of paraffins appreciably dissolving in the liquid sulphur dioxide.

Solubility of Olefins in Liquid SO_2

The solubility of olefins in liquid SO_2 is shown in Graph I. The behavior at —18 deg. and —10 deg. for 33.3 per cent and 66.7 per cent liquid SO_2 corresponds to that of the aromatics, namely, entire miscibility.

Solubility of Naphthenes in Liquid SO_2

The solubility of naphthene hydrocarbons is shown in Graphs I and II. Edeleanu (loc.cit.) and Browery (loc.cit.) both state that naphthenes are entirely insoluble in liquid sulphur dioxide and after treatment are left with the paraffins. The present work, however, indicates that naphthenes vary in solubility from 0 to 100 per cent depending on the temperature and concentration of the liquid SO_2. Graph II shows the solubility of pure cyclohexane at temperatures of —18 deg., —10 deg., —7.5 deg. and —4.5 deg. C. and at percentages SO_2 ranging from 45 to 91. Below 45 per cent SO_2, that is, nearly an equal volume, there is no solubility at —18 deg. C. and only 3 per cent at —4.5 deg. C. With about 70 per cent SO_2, however, the solubility shows a marked increase. The solubility also increases rapidly with temperature; with 89.4 per cent SO_2 the solubility is about 58 per cent at —18 deg. and 100 per cent at —4.5 deg. C. One marked peculiarity of the naphthene action with SO_2 is that as the concentration of SO_2 reached a point between 83 per cent and 87 per cent white crystals appeared in the oils, remaining upon addition of more SO_2.

TABLE III. SOLUBILITY OF NAPHTHENES IN LIQUID SULPHUR DIOXIDE

B P. of Naphthenes Used	Temp. °C.	% SO_2 Used	% Naphthene Dissolved
175°-185°	—10	50 0	0 0
175°-185°	—10	67 0	0.0
175°-185°	—10	75 0	0 0
175°-185°	—10	80 0	0.0
175°-185°	—10	81 8	4 0
175° 185°	—10	83 3	6.0
175°-185°	—10	85 5*	13 0
175°-185°	—10	87 5	16 5
175°-185°	—10	88 5	23.0
75°C-155°C	—10	50 0	0 0
75°C-155°C	—10	67 0	0.0
75°C-155°C	—10	75 0	4 0
75°C-155°C	—10	80 0	8 0
75°C-155°C	—10	83 3*	14.0
75°C-155°C	—10	83 9	15.0
75°C-155°C	—10	85 5	23.0
75°C-155°C	—10	87 5	30 0
75°C-155°C	—10	88 5	37.0

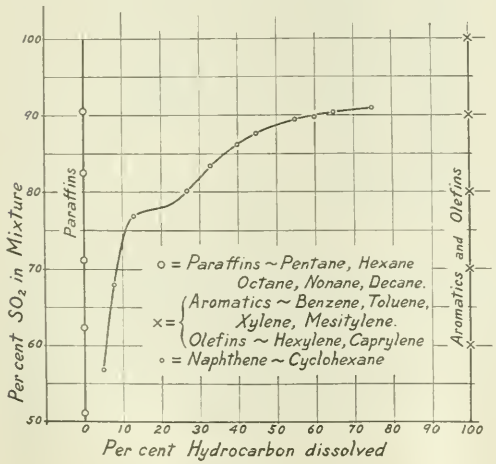
* Crystals formed.

TABLE IV. SOLUBILITY OF NAPHTHENES AT VARYING TEMPERATURES

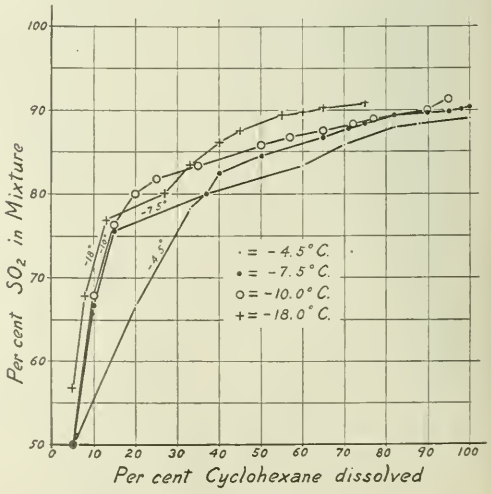
	—18° C.		—10° C.		— 0° C.	
	% SO_2	% Dissolved	% SO_2	% Dissolved	% SO_2	% Dissolved
155° 175°	50 0	0	50 0	0	50 0	0
155°-175°	66 7	0	66 7	0	66.7	0
155°-175°	75 0	0	75 0	0	75 0	0
155°-175°	80 0	0	80.4	2	80.0	2 0
155°-175°	83.0	2	81 8	7	81 5	8 0
155°-175°	84 4	5	84 1	9	83 1	11.0
155°-175°	86 9	5	86 5	12	84 9*	15 0
155°-175°	87 2*	6	87 3*	14	86.3	20 0
155°-175°	89 2	18	87 8	17	87.35	24 0
155°-175°	90 5	25	88 6	19	88 9	28.0
155°-175°			88.9	20	89.25	30.0
155°-175°	Remainder Dissolves		89 4	22	89.5	32.0
155°-175°	When Warmed		90 0	28	90 2	39.0

* At this conc. SO_2 a white crystalline solid appears in oil and remains.

This peculiarity of behavior together with the rather marked increase in solubility at about 70 per cent SO_2 seems to point to some compound between the SO_2 and


Per cent SO_2 in Mixture
Per cent Hydrocarbon dissolved
Paraffins
Aromatics and Olefins
o = Paraffins ~ Pentane, Hexane Octane, Nonane, Decane.
x = Aromatics ~ Benzene, Toluene, Xylene, Mesitylene. Olefins ~ Hexylene, Caprylene
◦ = Naphthene ~ Cyclohexane

GRAPH 1.



GRAPH 2.

the naphthenes. The literature contains examples of compounds forming between liquid SO_2 and organic substances. For instance, De Bruin,[6] mixed isoprene with an equal volume liquid SO_2 and obtained a crystalline compound of the composition $C_5H_8.SO_2$ of definite melting point, 62.5 deg. Baumé and Pamfel[7] working with liquid SO_2 and methyl alcohol found indications of the formation of $CH_3OH.SO_2$ and $2CH_3OH.SO_2$. The case in question does not seem to be plain solubility but probably formation of a compound which is stable only at low temperatures and in the presence of considerable SO_2. Further investigation on this point is being conducted.

The naphthenes of higher boiling-point (Tables III and IV) show a much smaller solubility than cyclohexane. The fraction 175 deg. — 185 deg. is insoluble up to 80 per cent. SO_2 but shows a marked increase from there on, giving a solubility of 23 per cent upon the addition of only 8.5 per cent more SO_2.

One of the difficult problems heretofore in oil work has been the determination of naphthenes in the presence of paraffins. The usual method has been merely a calculation based on the boiling point, index and specific gravity of the unvitratable oil;[8] while Kramer and Bottcher's method involves fractionation to within one or two degrees and carbon and hydrogen determinations of these fractions to estimate naphthenes present. These methods obviously are proximate at best, the second one involving considerable manipulation. The action of liquid sulphur dioxide therefore may prove a valuable aid not only in estimating napthenes in paraffins but separating them for further test. The application of this method to the separation of synthetic mixtures of naphthenes and paraffins is given later.

ACTION OF SULPHUR DIOXIDE ON SYNTHETIC MIXTURES

The work on synthetic mixtures is divided into six sections, as follows:

A.—Paraffin-Aromatic Mixtures.
B.—Naphthene-Aromatic Mixtures.
C.—Paraffin-Olefin Mixtures.
D.—Paraffin-Naphthene Mixtures.
E.—(a) Olefin-Naphthene Mixtures.
(b) Olefin-Aromatic Mixtures.
F.—Paraffin-Aromatic-Olefin Mixtures.:

A.—Paraffin-Aromatic Mixtures

Benzene-Hexane, Table V.
Toluene-Octane, Table VI.
Toluene-Kerosene, Table VII.

Although the aromatic oils are entirely miscible with the solvent used, while paraffin oils are insoluble, the paraffin-aromatic mixture treated with the solvent presents many complexities. In the first place, the system aromatics-sulphur dioxide has a capacity for dissolving paraffins which sulphur dioxide alone has not. This is shown in the above tables by the increasing solubility of the paraffins as the percentage of aromatics in the mixture is increased. With 50 per cent benzene present, the paraffin-aromatic mixture is 100 per cent soluble. This is true also for the toluene-paraffin mixtures. The extraction of aromatics by sulphur dioxide is, therefore, limited to mixtures containing below 50 per cent aromatics, and efficient extraction is possible only below 25 per cent aromatics. Table V shows that from a mixture containing only five per cent benzene, it is possible with one extraction to separate an oil of 88.3 per cent benzene content, using an equal volume of sulphur dioxide. The percentage of benzene content is calculated, in each case, from the index of refraction, using the formula

$$\frac{(m - p)100}{a - p} = \text{aromatics}$$

where m = index of mixture;
p = index of paraffins used;
a = index of aromatics used.

As the percentage of benzene in the original mixture is increased, the solubility of the mixture rapidly increases, the bulk of the aromatics being extracted. With 15 per cent benzene in the mixture it is possible to separate nearly all the aromatics, the extraction representing 76.5 per cent benzene. Both the toluene and benzene mixtures show best extractions when the aromatics are present to an extent not exceeding 20 to 25 per cent. Certain natural petroleums which contain aromatics usually are under 15 per cent in aromatics content, and therefore lend themselves admirably to the sulphur dioxide extraction. This ideal percentage of about 15 per cent aromatics was used by Browery (loc.cit.) in extractions with sulphur dioxide and yielded

TABLE V. SEPARATION OF PARAFFIN-AROMATIC MIXTURES

Benzene — Specific Gravity, 0 880; Index of Refraction, 1 5014
Pentane and Hexane — Specific Gravity 0 650; Index of Refraction, 1 3700

Temp °C	% Mixture Paraffin	% Mixture Benzine	% Mixture Used	% SO_2 Added	% of Oil Mixture Dissolved	Dissolved Index	Dissolved Butane Calculated	Undissolved
18	95 0	5 0	50 0	50 0	5 0	1 4860	88 3	1 3741
18	90 0	10 0	50 0	50 0	15 0	1 4786	82 6	1 3753
18	85 0	15 0	50 0	50 0	28 5	1 4705	76 5	1 3770
18	80 0	20 0	50 0	50 0	32 5	1 4593	67 9	1 3814
18	50 0	50 0	50 0	50 0	100 0			

TABLE VI. PARAFFIN-AROMATIC MIXTURES.

Toluene — Specific Gravity, 0 870; Index of Refraction 1 4982
Octane — Specific Gravity, 0 706 Index of Refraction, 1 3999

Temp °C	% Octane in Mixture	% Toluene in Mixture	% of Mixture Used	% SO_2 Used	% Oil Mixture Dissolved	Index of Dissolved Oil	Index of Undissolved Oil
18	95 0	5 0	50 0	50 0	1 5	1 4092	1 4600
18	90 0	10 0	50 0	50 0	5 0	1 4075	1 4694
18	85 0	15 0	50 0	50 0	14 5	1 4040	**1 4792
18	80 0	20 0	50 0	50 0	19 0	1 4018	1 4688
18	75 0	25 0	50 0	50 0	27 0	1 4024	1 4554
18	50 0	50 0	50 0	50 0	100 0		
18	50 0	50 0	30 0	70 0	92 5		
18	50 0	50 0	18 5	81 5	93 0		
18	50 0	50 0	15 2	84 8	100 0		

** = 86 8% Toluene.

TABLE VII. PARAFFIN-AROMATIC MIXTURES

Kerosene — Specific Gravity, 0 779. Index of Refraction, 1 4277
Toluene Specific Gravity, 0 870; Index of Refraction, 1 4982

Temp. °C	% Kerosene in Mixture	% Toluene in Mixture	% of Mixture Used	% SO_2 Used	% Oil Mixture Dissolved	Index of Dissolved Oil	Index of Undissolved Oil
—18	90 0	10 0	50 0	50 0	5 5	1 4732	1 4311
—18	85 0	15 0	50 0	50 0	14 3	1 4794	1 4308
—18	80 0	20 0	50 0	50 0	19 0	1 4813	1 4302
—18	75 0	25 0	50 0	50 0	22 0	1 4789	1 4312
—18	95 0	5 0	54 0	46 0	2 5		
—18	95 0	5 0	39 2	60 8	6 3	1 4659	1 4285
—18	95 0	5 0	33 3	66 7	10 0		
—18	95 0	5 0	19 5	80 5	20 0		
—18	95 0	5 0	19 0	81 0	20 0		
—18	95 0	5 0	15 0	85 0	20 0	1 465	1 4782
—18	50 0	50 0	73 0	27 0	100 0		
—18	50 0	50 0	59 4	40 6	74 5		
—18	50 0	50 0	50 6	49 4	62 5		
—18	50 0	50 0	41 7	58 3	62 3		
—18	50 0	50 0	38 0	62 0	65 0		
—18	50 0	50 0	29 1	70 9	68 7		
—18	50 0	50 0	22 6	77 4	72 6	1 4715	1 4494

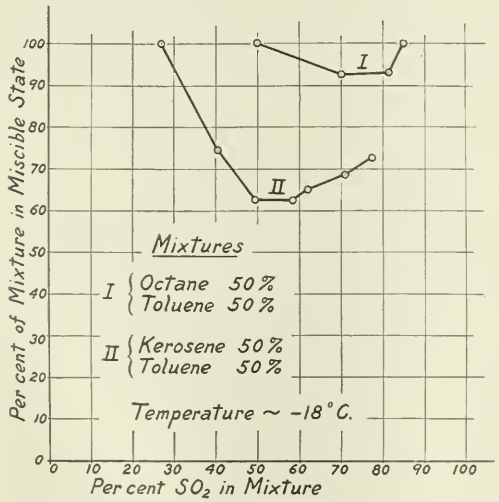
[6] Proc. K. Akad. Wetenseh. Amsterdam, 17,585, 1914
[7] Compt. Rend., 152,1095, 1911
[8] Engler-Hofer, Das Erdöl, on Naphthenes.

satisfactory results, especially when a number of extractions were made, using each time small quantities of the solvent.

In Table VI, a mixture containing 15 per cent toluene and 85 per cent octane yields an extraction equal to 14.5 per cent of the entire volume. The index of this extraction denotes 86.8 per cent toluene. This is a little better extraction than can be obtained from a kerosene-toluene mixture which under the same conditions yields a 73.3 per cent toluene in one extraction. By extracting a number of times with small quantities of the solvent, much purer aromatics may be separated.

The effect of extracting with various concentrations of the solvent, keeping the concentration of the mixed oils constant, led to interesting results which should receive discussion. Table VII shows that using a constant mixture of 95 per cent kerosene and 5 per cent toluene, and increasing the amount of sulphur dioxide added from 50 per cent to 85 per cent, the amount dissolved increased to a maximum of 20 per cent with 80.5 per cent solvent. Further addition of sulphur dioxide effected no further dissolving. A marked peculiarity in behavior, however, was noticed on 50 per cent mixtures of kerosene and toluene with increasing addition of solvent. With 27 per cent solvent the mixture was completely soluble. As the amount of solvent increased, less and less of the mixture dissolved until at 58.3 per cent solvent, a minimum solubility of 62.3 per cent of oil was reached. With further addition of solvent, the solubility increased. This peculiar behavior is also shown by the octane-toluene mixtures and is deemed sufficiently interesting to be shown graphically in Graph III. This retrograde solubility is evidence of the complexity of the aromatic-paraffin-sulphur dioxide system, a three-component system, for starting with a homogeneous system we pass to a heterogeneous system and finally to a homogeneous system again, merely by altering one concentration.

In Tables V, VI and VII, the purity of the dissolved and the undissolved oils can be ascertained by comparing their indices of refraction with the indices of the original oils as given under the heading of each table. For instance, in Table VI, the indices of the undissolved oils, in each case, are very close to the value for the pure octane, i.e., 1.3999, showing that virtually all of the aromatics have been removed .



GRAPH 3.

B.—Aromatic-Naphthene Mixtures

Benzene-Cyclohexane, Table VIII.
Xylene-Naphthenes, Table IX.

TABLE VIII. SEPARATION OF AROMATIC-NAPHTHENE MIXTURES

(Aromatic)—Benzene— Specific Gravity, 0.880; Refractive Index, 1.5014
(Naphthene)—Cyclohexane Specific Gravity, 0.780; Refractive Index, 1.4255

Temp. °C.	% Benzene in Mixture	% Cyclohexane in Mixture	% Mixture Used	% SO_2 added	% Oil Mixture Dissolved	Index of Dissolved Oil	Index of Undissolved Oil
—18	10.0	90.0	73.0	27.0	0.0	.....	.....
—18	10.0	90.0	60.0	40.0	5.0	1.4992	1.4258
—18	10.0	90.0	55.0	45.0	12.0	1.4965	1.4262
—18	10.0	90.0	50.0	50.0	22.5	1.4602	1.4261
—18	15.0	85.0	75.0	25.0	26.0	1.4616	1.4269
—18	15.0	85.0	67.0	33.0	28.0	1.4613	1.4271
—18	15.0	85.0	55.0	45.0	30.0	1.4608	1.4271
—18	15.0	85.0	50.0	50.0	32.5	1.4600	1.4276
—18	25.0	75.0	50.0	50.0	48.0	1.4608	1.4279
—18	25.0	75.0	25.0	75.0	62.0	1.4590	1.4274
—18	50.0	50.0	50.0	50.0	100.0	.....	.....
—18	50.0	50.0	45.0	55.0	100.0	.....	.....
—18	50.0	50.0	40.0	60.0	100.0	.....	.....

TABLE IX. SEPARATION OF AROMATIC-NAPHTHENE MIXTURES

Xylene—Refractive Index..... 1.4989
Naphthenes—Refractive Index..... 1.4345

Temp. °C.	% Xylenes in Mixture	% Naphthenes in Mixture	% of Mixture Used	% SO_2 added	% Mixture Dissolved	Index of Dissolved Oil	Index of Undissolved Oil
—18	5.0	95.0	50.0	50.0	3.2	1.4961	1.4398
—18	10.0	90.0	50.0	50.0	8.0	1.4918	1.4410
—18	15.0	85.0	50.0	50.0	13.8	1.4893	1.4411
—18	20.0	80.0	50.0	50.0	20.0	1.4879	1.4403
—18	25.0	75.0	50.0	50.0	30.0	1.4845	1.4415
—18	50.0	50.0	50.0	50.0	72.5	1.4722	1.4592
—18	60.0	40.0	50.0	50.0	100.0	.....	.....

In the experiments on the solubility of pure naphthenes, it was found that only a slight amount of this type hydrocarbon dissolved when less than 50 or 60 per cent of sulphur dioxide was used. It will be recalled that their solubility increased rapidly as the amount of solvent reached 75 to 80 per cent. It seemed probable, therefore, that aromatics which are completely miscible with sulphur dioxide, might be separated from the naphthenes if the percentage of solvent was kept low. The results given in Tables VIII and IX show this to be true. From a mixture containing only 10 per cent benzene and 90 per cent naphthenes it was possible to separate almost pure benzene, using equal volumes (50 per cent) of the solvent. The 15 per cent benzene mixtures also show a fairly good separation. But as the benzene content of the starting mixture increases, the sulphur dioxide-benzene mixture seems to form a solvent for the naphthenes, so that with 50 per cent aromatics present, the naphthenes are entirely miscible with 50 per cent sulphur dioxide. This is analogous to the solubility of paraffins in aromatics-sulphur dioxide mixtures. The xylene-naphthene mixtures (Table IX) show by comparison of the indices of refraction with the original oils, fairly satisfactory separations. In this case, as in the aromatic-paraffin separations, cleaner separations are possible with smaller amounts of xylene in the mixture. This is due to the solvent action of naphthenes of the xylene-sulphur dioxide complex, which is strengthened with increasing proportions of the aromatic. In no case in the naphthene-aromatic work was there noticed the peculiar retrograde solubility shown by the paraffin-aromatics.

C.—Paraffin-Olefin Mixtures

Hexane-Hexylene, Table X.

Pentane-Amylene, Table XI.

Pure olefins are entirely miscible with sulphur dioxide, while paraffins are insoluble. Tables X and XI show that olefins may be separated rather closely from mixtures which are not richer in olefins than about 20 to 25 per cent. In mixtures richer than 25 per cent the olefins and sulphur dioxide act as a solvent for the paraffins so that with 50 per cent olefins we have homogeneous systems formed. For paraffins containing under 20 per cent olefins, however, the indices of refraction show very good separations. The refining of gasolenes and kerosenes to free from unsaturated hydrocarbons is readily accomplished by liquid sulphur dioxide since in natural petroleums the percentage of olefins rarely is over 10 or 15 per cent, and usually not so high.

TABLE X. SEPARATION OF PARAFFIN-OLEFIN MIXTURES

(Paraffins)—Pentane and Hexane—Refractive Index, 1 3629
(Olefin)—Hexylene —Refractive Index, 1 3994

Temp. °C.	% Hexylene in Mixture	% Paraffins in Mixture	% Mixture Used	% SO_2 Used	% Oil Mixture Dissolved	Index of Dissolved Oil	Index of Undissolved Oil
—18	5.0	95 0	50.0	50 0	1 3	1 3978	1.3678
—18	10 0	90 0	50 0	50 0	5 0	1.3935	1.3689
—18	15 0	85 0	50.0	50.0	6 5	1.3918	1.3789
—18	20 0	80 0	50 0	50 0	7 5	1.3905	1 3791
—18	25.0	75 0	50 0	50.0	20 0	1.3873	1.3803
—18	50 0	50.0	50.0	50 0	100 0	.....	.....

TABLE XI. SEPARATION OF PARAFFIN-OLEFIN MIXTURES

(Paraffin)—Pentane—Index of Refraction 1.3629
(Olefin) —Amylene—Index of Refraction 1.3880

Temp. °C.	% Amylene in Mixture	% Pentane in Mixture	% of Mixture Used	% SO_2 Used	% Oil Mixture Dissolved	Index of Dissolved Oil	Index of Undissolved Oil
—18	5.0	95 0	50.0	50 0	2.7	1 3875	1.3634
—18	10 0	90 0	50.0	50.0	6.6	1.3868	1 3650
—18	15 0	85.0	50.0	50.0	10.5	1.3821	1 3676
—18	20.0	80 0	50.0	50.0	14.2	1.3792	1 3690
—18	25 0	75.0	50.0	50.0	20.5	1.3774	1.3705
—18	50.0	50 0	50 0	50.0	100.0	.....	.....

D.—Paraffin-Naphthene Mixtures

Nonane-Cyclohexane, Table XII.

Gasolene-Naphthenes (75 deg. — 155 deg.), Table XIII.

Gasolene-Naphthenes (175 deg. — 200 deg.), Table XIV.

Paraffins (175 deg. — 200 deg.)-Naphthenes (175 deg. — 200 deg.), Table XV.

Although the literature[5] on sulphur dioxide refining of oils states that naphthenic hydrocarbons are as insoluble in sulphur dioxide as the paraffins and remain undissolved with them after the aromatics and unsaturateds are removed, the present work on individual naphthenes indicates that these hydrocarbons may be entirely dissolved, providing sufficient solvent is added. This solubility curve takes a sharp rise when about 85 per cent of the solvent is added, indicating the formation of a chemical complex. The crystals formed at about this concentration offer further evidence in support of this assumption.

Since this difference in solubility exists, the separation of naphthenes from paraffins was investigated, with a satisfactory degree of success as shown in Tables XII, XIII, XIV and XV.

[5] Cf. Edeleanu (loc. cit.) and Browery (loc. cit.)

Comparing, in these tables, the index of the dissolved and undissolved portions with the indices of the original oils, we find in every experiment considerable separation and in certain cases very close separation. It will be noticed that when only an equal quantity of solvent was added no separation occurred, but that the solubility of the naphthenes was marked when over 80 per cent solvent was used. Thus, in Table XII, when to a mixture of 15 per cent cyclohexane in 85 per cent paraffins, 86.7 per cent sulphur dioxide was added, a separation of 15 per cent oil took place. The index of this soluble portion was 1.4205 compared with 1.4255 for the pure cyclohexane, a very satisfactory separation. The other tables show equally good separations for mixtures containing up to 25 per cent naphthenes. Above this percentage separations are not as clean cut, the paraffins tending to dissolve in the naphthene-sulphur dioxide system.

TABLE XII. SEPARATION OF PARAFFIN-NAPHTHENE MIXTURES

(Paraffins) —Nonane + decane; Sp.Gr. = 0.730; Index of Refraction 1.4174
(Naphthene)—Cyclohexane; Sp.Gr. = 0.780; Index of Refraction 1.4255

Temp. °C.	% Paraffin in Mixture	% Naphthene in Mixture	% of Mixture Used	% SO_2 Added	% Oil Mixture Dissolved	Index of Dissolved Oil	Index of Undissolved Oil
—18	85.0	15 0	50 0	50 0	0 0	.	.
—18	85 0	15 0	31 2	68 8	0 0	..	
—18	85 0	15 0	24 4	75.6	0 0	. .	
—18	85.0	15 0	19.2	80.8	0 0		
—18	85.0	15.0	18.2	81 8	2 0	1 4250	1 4189
—18	85.0	15 0	15.4	84 6	7 0	1 4247	1 4183
—18	85.0	15 0	13.3	86.7	15.0	1.4244	1 4185
—18	85.0	15.0	10.0	90.0	15.0	1 4237	1 4187

TABLE XIII. SEPARATION OF PARAFFIN-NAPHTHENE MIXTURES

Gasolene Specific Gravity = 0 721; Index of Ref. 1 4008
Naphthene (75°–155°) Specific Gravity = 0 784; Index of Ref. 1 4267

Temp. °C.	% Paraffins in Mixture	% Naphthenes in Mixture	% of Mixture Used	% SO_2 Added	% Mixture Dissolved	Index of Dissolved	Index of Undissolved
—18	95.0	5 0	50 0	50.0	0	.	. . .
—18	90 0	10 0	50 0	50 0	0		.
—18	85.0	15 0	50 0	50 0	0		
—18	80.0	20 0	50.0	50.0	0	..	
—18	75.0	25.0	50 0	50 0	0	.	...
—18	50.0	50 0	50 0	50 0	0		
—18	75.0	25.0	47 5	52 5	0		
—18	75.0	25.0	38.0	62.0	2 5	1.4258	1.4012
—18	75.0	25.0	34 8	65 2	3.5	1 4251	1.4029
—18	75.0	25.0	27.6	72 4	12.5	1.4215	1.4038
—18	75.0	25.0	20.5	79 5	23.0	1.4189	1 4041
—18	75.0	25.0	17.8	82 2	25.0	1 4172	1 4058

TABLE XIV. SEPARATION OF PARAFFIN-NAPHTHENE MIXTURES

Gasolene—Index of Refraction 1 4187
Naphthenes—Index of Refraction 1 4460

Temp. °C.	% Naphthenes in Mixture	% Paraffins in Mixture	% of Mixture Used	% SO_2 Added	% Mixture Dissolved	Index Dissolved Oil	Index Undissolved Oil
—18	5.0	95.0	15 0	85 0	2 5	1 4455	1 4188
—18	10.0	90.0	15.0	85.0	6 6	1 4442	1 4192
—18	15 0	85.0	15.0	85.0	10.0	1 4415	1 4199
—18	20 0	80.0	15 0	85.0	13 4	1 4395	1 4211
—18	25 0	75.0	15 0	85.0	19 2	1 4386	1 4222
—18	50.0	50.0	6.0	94 0	35 0	1 4322	1 4239

TABLE XV. PARAFFINS-NAPTHENES MIXTURES

Paraffins B.P. = 175°–200°C; Sp.G. = 0 781; Index = 1 4277
Naphthenes B.P. = 175°–200°C; Sp.G. = 0.824, Index = 1 4460

Temp. °C	% Paraffins in Mixture	% Naphthenes in Mixture	% SO_2 Used Twice Volume of Oil	% Dissolved Oil	Index	Undissolved Index
—15°	85	15		13	1 4450	1 4282

Table XIII gives the results of a run on 150 cc. of mixture containing 15 per cent of naphthenes boiling

from 175 deg. to 200 deg., and 85 per cent of paraffins of the same boiling point. In one treatment, using twice the volume of solvent as of oil, 13 per cent of the oil dissolved. The index of this portion showed almost pure naphthenes.

Heretofore there has been no method of separating naphthenic from paraffin hydrocarbons. The determination of such a mixture in the past involved fractionation to one or two degrees and analysis of the carbon and hydrogen content. Liquid sulphur dioxide, therefore, may prove a valuable aid in such a determination, particularly as the naphthenes are recovered and may be used for further physical and chemical tests. Moreover, since naphthenes have been regarded as the best lubricants of all hydrocarbons, the separation of these, almost pure, may prove of commercial value in the refining of such oils.

E.—(a) Olefin-Naphthene Mixtures, Table XVI
(b) Olefin-Aromatic Mixtures, Table XVII

TABLE XVI. SEPARATION OF OLEFIN—NAPTHENE MIXTURES

Octylene—Index of Refraction 1.4145
Naphthenes—Index of Refraction 1.4267

Temp. °C.	% Olefin in Mixture	% Naphthene in Mixture	% of Mixture Used	% SO_2 Used	% of Oil Mixture Dissolved	Index of Dissolved Oil	Index of Undissolved Oil
—18	10.0	90.0	50.0	50.0	8.5	1.4147	1.4263
—18	20.0	80.0	50.0	50.0	17.0	1.4156	1.4259
—18	50.0	50.0	50.0	50.0	46.0	1.4162	1.4250

TABLE XVII. OLEFIN-AROMATIC MIXTURES

Benzene—Index of Refraction 1.5014
Hexylene—Index of Refraction 1.3994

Temp. °C	% Olefin in Mixture	% Aromatic in Mixture	% Mixture Used	% SO_2 Added	% Oil Dissolved
—18	20.0	80.0	50.0	50.0	100.0
—18	50.0	50.0	50.0	50.0	100.0

(a) Olefin-Naphthene Mixtures. For this separation was used a mixture of octylene (index 1.4145) and naphthenes boiling between 75 deg. and 155 deg. (index 1.4267). The results are shown in Table XVI. Using a volume of solvent equal to the volume of oils, it was possible to make very close separations on mixtures containing as high as 50 per cent olefins. The separation of practically pure olefins from naphthenes is possible with sulphur dioxide, providing that not higher than 50 per cent of the solvent is used. This percentage of solvent must not be greatly increased since the naphthenes themselves become appreciably soluble with increasing amounts of sulphur dioxide.

(b) Olefin-Aromatic Mixtures. Olefins and aromatics are each entirely miscible with liquid sulphur dioxide, and, as would be expected, their mixtures in different proportions were entirely soluble. These runs are shown in Table XVII.

F.—Paraffin-Aromatic-Olefin Mixtures

Separation of Gasolene, Xylene, Octylene, Table XVIII.

Table XVIII gives the result of adding equal volumes of sulphur dioxide to gasolene containing varying proportions of xylene and the olefin octylene. The latter two, when present to an extent not exceeding 25 per cent of the volume of the oil, could be quite readily and almost completely removed as the refraction indices of the separated oils indicate. It is this separation which can be very usefully applied to the refining of American petroleums since the aromatics and olefins

TABLE XVIII.—PARAFFIN-AROMATIC-OLEFIN MIXTURES

	Sp. G.	Index
(Paraffin)—Gasolene	0.721	1.4008
(Aromatic)—Xylene	0.880	1.4989
(Olefin)—Octylene	0.724	1.4145

Temp. °C	% Paraffin in Mixture	% Aromatic in Mixture	% Olefin in Mixture	% Mixture Used	% SO_2 Added	% Oil Dissolved	Index of Dissolved Oil	Index of Undissolved Oil
—18	95.0	3.3	1.7	50.0	50.0	4.0	1.4889	1.4010
—18	90.0	6.7	3.3	50.0	50.0	9.5	1.4868	1.4013
—18	85.0	10.0	5.0	50.0	50.0	12.0	1.4836	1.4065
—18	80.0	13.3	6.7	50.0	50.0	17.5	1.4818	1.4087
—18	75.0	16.7	8.3	50.0	50.0	31.5	1.4527	1.4157
—18	50.0	33.3	16.7	50.0	50.0	100.0	.....	.....

are considerably below the 25 per cent limit. Moreover, the olefins and aromatics are readily recovered from the sulphur dioxide, a fact which is in marked contrast with the present oil-refining losses due to the removal of unsaturateds with sulphuric acid.

As the percentage of aromatics and unsaturateds exceeded 25 per cent of the mixture, the solubility of the paraffins became more marked. With 50 per cent aromatics and olefins present, the mixture was entirely miscible with the solvent.

This separation was checked up on crude unwashed Pennsylvania gasolene and kerosene. In each case the sulphur dioxide dissolved more than was removed by the sulphonation for olefins and nitration treatment for aromatics. The index of the oil treated with sulphur dioxide showed much purer paraffin hydrocarbons remaining, while the dissolved olefins and aromatics were recovered.

Summary

1. The solubilities of a number of pure aromatics, pure paraffins, pure olefins and naphthenes in liquid sulphur dioxide have been determined for various concentrations.

2. Naphthenes, which the literature states are insoluble, may be completely dissolved in sufficient quantities of the solvent.

3. In order to investigate the utility of the liquid sulphur dioxide method for oil refining and also for analytical work, a number of separations were attempted on mixtures of the above types of hydrocarbons in various proportions. It has been found that within certain limiting concentrations,

a—aromatics may be separated from paraffins or naphthenes

b—olefins may be separated from paraffins or naphthenes

c—aromatics and olefins together may be separated from paraffins or naphthenes

d—naphthenes may be separated from paraffins.

4. The application of the liquid sulphur dioxide method to analytical work on oils is of importance since the separated unsaturateds or aromatics may be recovered and their identity proven by further physical tests. In sulphonation for olefins and nitration for aromatics these oils are lost. Moreover, naphthenes may be separated from paraffins within prescribed limits, a fact that will appeal to the oil analyst.

5. The application of the sulphur dioxide method to oil refining may prove of importance since the valuable aromatics and unsaturated hydrocarbons are recovered, the refined oil is purer than the acid method yields, and the sulphur dioxide may be applied and recovered in a continuous cycle.

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Standardization of Base-Metal Thermocouples*

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A FORM of furnace especially adapted to the rapid testing of a large number of couples consists of a tube of pure nickel or nickel-chromium alloy (chromel) clamped between two water-cooled terminals. A heavy current from a suitable transformer is passed through the tube, the tube itself serving as the heating element or resistor. For use with base-metal couples a porcelain insulating tube may be placed inside the metal tube or the base-metal couple may be wound with asbestos cord to electrically insulate it from the walls of the tube. In this case the standard couple, insulated in a non-porous porcelain tube, is placed with its hot junction as near as possible to the hot junction of the base-metal couple. Rare-metal couples may be standardized by taking proper precautions to prevent contamination by the metal vapors from the heating unit. The heating tube of this furnace is exposed to the air and no thermal insulating material is employed. A large concentric tube may be mounted around the heating tube to reduce the radiation loss, although this is not necessary. A furnace of this type may be heated very rapidly to any temperature up to 1100 deg. C. and it is possible to completely calibrate a couple at 5 or 6 different temperatures in a half hour.

Calibration of Base-Metal Couples

It is difficult to secure equality of temperature between the hot junctions of two base-metal couples or between a base-metal and a rare-metal couple. One arrangement for precision calibration is to place the junction of the rare-metal couple in a small saw-cut made in the hot junction of the base-metal couple and pinch the jaws of the saw-cut until good thermal contact is secured. The rare-metal couple is protected by porcelain tubes to within a few millimeters of the hot junction and the end of the porcelain tube is sealed to the couple by a small amount of kaolin and water-glass cement. This prevents contamination of the rare-metal couple with the exception of the small length of 2 or 3 mm. which is necessarily exposed to the metal vapors. If the furnace is uniformly heated in this region, a small amount of contamination will not cause any error. The method however is not feasible for work on a large scale.

Use of a Muffle Furnace

Several base-metal couples and the standard rare-metal couples mounted in non-porous porcelain tubes are packed together as closely as possible and tied into a bundle with asbestos cord. The hot junctions are inserted into a length of very heavy iron pipe capped at one end, and the open end from which the couples protrude is tightly packed with asbestos wool. The iron tube and couples are mounted in the furnace and the electromotive-force measurements are made as soon as temperature equilibrium is reached. If the muffle furnace is large enough, the iron tubes protecting the base-metal couples need not be removed. A satisfactory size of furnace measures 8 in. by 8 in. by 30 in. deep. Precision work is impossible in this method of calibration. Even when every precaution is taken to reduce temperature gradients, differences in temperature of 10 deg. or 20 deg. C. frequently will be found to exist between the different couples mounted side by side. However, this accuracy is sufficient for many industrial processes.

Use of Molten Metal Bath

The most satisfactory method for calibrating base-metal couples on a large scale is by use of a bath of molten metal. An iron pot about 12 in. diameter or larger and 15 in. deep is filled with tin covered with powdered graphite. This may be heated in a gas furnace or an electric furnace wound with nickel alloy such as nichrome or chromel. Into the tin bath dip about six iron tubes closed at the lower end and immersed to a depth of 12 in. The tubes are just large enough to permit easy insertion of the base-metal couple with its iron protecting tube. The standard couple is mounted in one of the six tubes and the base-metal couples are placed in the others. As soon as temperature equilibrium is reached the electromotive forces are measured, that of the standard couple giving the temperature of the bath. A large number of base-metal couples may be tested one after the other at this temperature and the process is then repeated at another temperature. The tin bath may be used satisfactorily in the range 300 deg. C. to 1000 deg. C. since tin is a metal of low volatility.

The method may be improved by operating the furnace and standard couple in connection with a temperature-control apparatus so that the temperature of the bath remains constant during a series of measurements. This advantage, however, is offset by the extra expense and complication of additional apparatus and in general is unnecessary. Data obtained by the above method are plotted, temperature versus electromotive force, for each couple, and a smooth curve drawn representing the calibration. For some types of base-metal couple the curve is slightly S-shaped showing small inflections near the critical points of the metals of which the couple is constructed. In precision work the calibration must be made at short temperature intervals over these critical regions to determine the exact form of the temp.-emf. curve.

Single Point Calibration or Check Point

It is frequently desirable to check a base-metal couple at a single point. If the couple is reading electromotive forces say 2 per cent higher at this temperature than the usual electromotive force or that shown by the

* The second of a series of two articles dealing with the pyrometer laboratory for industrial purposes. The first article dealt with rare-metal thermocouples.

original calibration data it is customary to assume that it reads 2 per cent high at all temperatures. This method of calibration at best is only approximate and experimentally it is frequently found that a couple reading 2 per cent high at 800 deg. C. indicates correctly at 1000 deg. C. However, single point calibrations are of value especially as a check upon the behavior of any particular couple.

A convenient standard temperature for this work is the melting or freezing point of sodium chloride (common salt), chemically pure. This material melts or freezes at 801 deg. C. The salt may be used in a nickel or duriron crucible heated in a gas or electric furnace. The base-metal couples are immersed several inches in the bath and melting or freezing point curves observed as discussed in a previous article.[1] If the salt has not been previously fused, it must be melted the first time with a cover on the crucible as the imprisoned water in the salt crystals will cause the salt to sputter out badly. After the first melt, however, there will be no trouble in the use of this material. Molten salt reacts somewhat with most base-metal couples but the reaction is so slow that the couple will not be injured. The Bureau has not found any serious change in melting point resulting from heating the salt in contact with iron for several hours.

Calibration of Thermocouples with Millivoltmeter or Indicating Instrument

When a thermocouple in a furnace is connected to a millivoltmeter, the electromotive force of the couple causes a current to flow around the circuit, which, in accordance with Ohm's law is equal to e/R where e is the electromotive force developed by the couple and R the total resistance of the circuit. The deflection of the pointer of the millivoltmeter is aproximately proportional to this current. Thus if the temperature of the furnace remains constant e is constant but the deflection of the instrument will be altered by changes in the resistance R. Hence any variation in R which produces a change in the reading of the instrument would be interpreted as a change in the temperature of the furnace although actually this is constant. The total resistance of the circuit may be divided into three parts, R_g the resistance of the millivoltmeter, R_L the resistance of the line, and R_c the resistance of the couple. If these resistances are properly proportioned the effect upon the reading of the indicator of any changes in the resistance R likely to occur can be reduced to practically zero. This condition is realized when R_g, the resistance of the galvanometer, is sufficiently high compared with $R_c + R_L$, the resistance of the external circuit. Suppose that the indicator has an electromotive force scale graduated to read the potential difference at its terminals. The relation between the reading of the instrument e_o and the true electromotive force e of the couple to which it is connected is given by the following equation:

$$e_o = \frac{R_g}{R_g + R_c + R_L} e$$

Thus if R_g is very large compared to $R_c + R_L$ the ratio $R_g/(R_g + R_c + R_L)$ is practically 1 and the reading of the galvanometer gives the true electromotive force of the couple.

[1] This journal, Apr. 1, 1918, p. 343.

Robust indicators are now obtainable having a resistance of 300 to 1200 ohms. As a particular example of the behavior of such an instrument, values of the factors occurring in the above equation will be considered for an actual thermocouple installation.

Galvanometer resistance $= R_g = 300$ ohms
Couple resistance $= R_c = 1$ ohms
Line resistance $= R_L = 1$ ohms

Whence

$$e_o = \frac{R_g}{R_g + R_c + R_L} e = \frac{300}{300 + 1 + 1} e = 0.993e$$

Thus, if the galvanometer is graduated to read potential differences at its terminals, the reading of the instrument gives the true electromotive force of the couple to within 0.7 per cent.

The construction of an indicator having a resistance of 300 ohms or more and having the necessary characteristics of robustness, portability, constancy in calibration, etc., is somewhat difficult. For this reason many manufacturers have secured these latter characteristics at a sacrifice of the desirable feature of high resistance. Instruments having a resistance of 10 ohms or less are in extensive use. Suppose a galvanometer, 10 ohms in resistance, calibrated to read potential differences at its terminals, is used in the circuit described above.

$$e = \frac{R_g}{R_g + R_c + R_L} e = \frac{10}{10 + 1 + 1} = 0.83e$$

Thus, if the galvanometer is graduated to read potential differences at its terminals, the electromotive force indicated by the instrument would be 17 per cent less than the true electromotive force of the couple. Such large errors are compensated for by arbitrarily graduating the scale to read the electromotive force of the couple when the resistance of the couple and line has a certain fixed value, in the above example 2 ohms. The instrument will accordingly read correctly for this external resistance but will read in error if the external resistance is altered. Bad contacts, deterioration of the couple from oxidation, change in depth of immersion, temperature coefficient of the copper lead wires, etc., may at any time alter the resistance of the external circuit. Let us compare the behavior of the 300-ohm instrument and the 10-ohm instrument, assuming both instruments are compensatingly graduated to read correctly for an external resistance of 2 ohms, when for one of the several reasons cited above the external resistance is increased by 1 ohm.

If the galvanometer were graduated to read potential differences at its terminals the relation between its reading e_o and the true electromotice force of the couple e would be given by the equation above. The instrument may be compensated so that its new reading, say e_o' is correct for some definite value of the external resistance. Inverting the former equation and putting $R_c + R_L + R' =$

$$e = \frac{R_g + R'}{R_g} e_o$$

It the compensated calibration is correct when $R' = R_o'$, then

$$e_o' = \frac{R_g - R_o'}{R_g} e_o$$

The per cent error in the reading e_o' due to a change

in R^1 is obtained by differentiating the following equation:

$$e_o^1 = \frac{R_g}{R_g + R^1} e_o$$

where R^1 is now a variable.

Per cent error in reading for change in R^1 of 1 ohm $= \frac{100 de_o^1}{e_o^1} = \frac{100 dR^1}{R_g} \frac{e_o}{e_o^1} = \frac{100 dR^1}{R_g} \frac{R_g + R_o^1}{R_o^1} = \frac{100(1)}{300 + 2} =$ 0.33% for 300 ohm indicator = about 3° at 1000° C. and $\frac{100(1)}{10 + 2} = 8.3\%$ for 10 ohm indicator = about 80° at 1000° C.

Thus when both instruments read correctly for an external resistance of 2 ohms, if the external resistance is increased by 1 ohm, the low resistance indicator is in error by 8.3 per cent while the high resistance instrument still reads practically correct. Considerations such as the above emphasize the importance of using a galvanometer having a resistance of 300 ohms or more. In actual operation the line resistance may change by several ohms on account of bad contacts and deterioration of the thermocouple.

The varying factor of line resistance has proven a strong argument in favor of a potentiometric method of measuring thermocouple electromotive force. A number of instruments based upon this principle are available. Besides the portable and laboratory types of potentiometer made by Leeds and Northrup there are special potentiometric galvanometer systems such as the pyrovolter made by the Pyrolectric Instrument Company, the Brown Heat Meter made by the Brown Instrument Company, and the Alladin made by Wilson-Maeulen. The high resistance galvanometer, however, is accurate enough for most purposes and possesses the advantages that it is less costly than the above instruments and that it indicates temperature continuously with no preliminary adjustments, while potentiometer installations require zero adjustments or balances on the standard cell, and except in the recording and deflecting potentiometers, a dial must be moved to obtain a setting.

Usually indicators are graduated to read temperature directly and do not have an electromotive-force scale. In this case they must be used with the type of couple for which the scale was designed. If the instrument has a resistance of more than 100 times the resistance of the external circuit no particular attention need be given to slight deviation from the prescribed resistance of the couple. The temp.-emf. relation of the couple for which the scale of the instrument is designed can be secured from the maker or can be determined in the laboratory by calibrating one of the couples as previously described.[3] The temp.-emf. relation can be also obtained directly from the temperature scale of the indicator by measuring with a potentiometer the potential drop across the terminals of the indicator when sufficient current is flowing through it to deflect the pointer to various scale readings. The reading of the potentiometer is equal to the emf. of the couple corresponding to a hot junction temperature given by the scale reading of the indicator and a cold junction temperature given by the reading of the indicator on open circuit. The various couples to be used with this instrument may be calibrated in the laboratory by use of a potentiometer. If the temp.-emf. relation of each couple agrees closely with that of the standard temp.-emf. curves, the couples are satisfactory to use with this indicator without applying corrections.

Suppose one particular couple develops 30 millivolts at 1000 deg. C. while the standard reference couple for which the instrument was calibrated develops 30 millivolts at a temperature of 1030 deg. C. The first couple will accordingly read too high by 30 deg. C. when corrected to the indicator. Proceeding in this manner a correction table can be prepared for each couple showing a temp.-emf. relation much different from that of the reference couple. It is of course possible to calibrate in the laboratory the couple and high resistance indicator as a unit. This, however, is not always convenient, especially if the indicator is of the wall type or is in constant use.

The calibration of couples for use with an indicator of low resistance can be made in the manner described above or the couple and indicator with lead wires of the same resistance as that used in the permanent installation may be calibrated as a unit. In the first method great care must be taken to see that the line resistance of the finally installed couple is correct. Manufacturers obtain the correct resistance by the use of a coil of resistance wire in series with the couple and mounted in the head of the couple. By properly adjusting the extra resistance slight deviations in the temp.-emf. relation for any particular couple from that of the reference couple for which the scale of the indicator was designed, may be partially corrected for. It is scarcely advisable for the industrial plant to make adjustments of this character. If low-resistance indicators are employed it is probably better to purchase of the manufacturer couples adjusted for a specified line resistance and for the particular indicator.

In the use of low-resistance indicators the resistance of the line and couple should be frequently checked. The resistance may be measured by means of a "test set" or portable Wheatstone bridge. Obtain a setting for resistance in the usual manner, then reverse the + and — terminals of the line and obtain a second setting. The mean of the two resistances gives the correct resistance of the circuit. The two settings will be different because of the electromotive force developed by the couple. Another method of measuring the resistance of a couple while hot, is given in Bureau of Standards Scientific Paper No. 250, page 147 .

Checking Thermocouples in Fixed Installations

It is frequently desirable to check the readings of a thermocouple without removing it from the furnace in which it is installed. Tests of this nature are of extreme importance in the technical industries. They are also difficult to perform with precision and the precision which is obtainable in a laboratory test can not be expected in tests of this nature. However, an ordinary calibration, in the laboratory, of a base-metal couple which has been in use in a fixed installation for some time, while furnishing results apparently of high precision, does not necessarily hold when the couple is returned to its original installation. This is on account of the heterogeneity developed in a base-metal couple after prolonged heating.

[3] This journal Apr. 1, 1918, p. 343.

The presence of heterogeneity could be detected by a homogeneity test but such tests on a large scale are not worth while for base-metal couples and moreover do not show how to correct the readings satisfactorily. Such a test would simply indicate that the couple should be thrown away whereas in its permanent installation it still has a useful life. The throwing away of base-metal couples in a fixed installation as soon as heterogeneity sets up would be a very costly and unnecessary procedure except in the comparatively rare cases where the highest possible accuracy is required. The degree of heterogeneity developed depends upon the type of installation, depth of immersion, location and character of temperature gradient, etc. These quantities are fairly definite and fixed for any particular installation. If, however, the couple is removed from the installation and calibrated in the laboratory these quantities are altered and the conditions under which the couple is actually operating can not be reproduced. The calibration in the laboratory may give results quite different from the calibration which would be obtained if it were possible to duplicate exactly all the physical characteristics of the permanent installation. Hence it is evident that if non-homogeneous couples are ever to be used, it is important that they be calibrated or checked in their fixed installation.

The exact method of procedure depends upon the type of installation. A standard checking couple is employed complete with a high-resistance galvanometer or portable potentiometer. The hot junction of the checking couple is placed as closely as possible to the hot junction of the couple under test and the readings of the two couples compared. The main objection to the method is the difficulty in getting the two hot junctions together. One method is to drill a hole in the furnace at the side of each couple permanently installed large enough to permit insertion of the checking couple. The hole is kept plugged except when comparison tests are being made. The checking couple is immersed in the furnace through this hole to the same depth as the couple under test. The hole should be located as close to the permanently installed couple as possible.

In many installations the base-metal couple and protecting tube are mounted inside another protecting tube of iron, fire clay, carborundum, or some other refractory which is permanently cemented or fastened into the furnace wall. Frequently there is room to insert a small test couple in this outer tube along side of the fixed couple. A third method, much less satisfactory, is to wait until the furnace has reached a fairly constant temperature and make observations with the couple under test, then remove this couple from the furnace and insert to the same depth the checking couple.

If desired, comparisons can be made preferably by either the first or second method at several temperatures and a curve may be obtained for each permanently installed couple showing the corrections necessary to apply to its readings.

It may be argued that this method of checking couples is unsatisfactory because in most furnaces used in industrial processes large temperature gradients exist and there is no certainty that the standard couple is at the same temperature as the couple under test. This objection, however, is not serious because if temperature gradients do exist, in the furnace, of such a magnitude as to cause much difference in temperature between two similarly mounted thermocouples, located closely together, the accuracy required by the measuring instruments need not be great, and the reading of the standard couple can be accepted for the standardization of fixed couple just as satisfactorily as if the true temperature of the fixed couple were known. If temperature gradients exist of such a magnitude that two correctly calibrated couples similarly mounted closely together read say 20 deg. C. apart, it may be certain that neither couple is registering the temperature of material within the furnace to this degree of accuracy.

Depth of Immersion of Thermocouple

Thermocouples immersed in furnaces of the various industrial types must be carefully protected. Heavy iron tubes and frequently larger auxiliary protecting tubes of various materials are employed. The thermocouple calibrated in the laboratory will give the temperature of the hot junction when installed in the protecting tubes but there is no certainty that this temperature is that of the furnace. Conduction along the protecting tubes may be so great that the temperature of the couple is far below that of the furnace. Conduction losses affecting the temperature of the hot junction may be reduced and even eliminated by using a sufficient depth of immersion but it is not always possible to do this and it is difficult to determine when the depth of immersion is sufficient. For example, an immersion of 5 cm. might be satisfactory for one type of furnace, or for a molten bath, and 30 cm. insufficient for a certain muffle furnace.

Each particular case requires special consideration.

The general practice is to use as deep immersion as is conveniently possible and trust that this is satisfactory. Two methods may be suggested for investigating the question but neither one is very conclusive. First, remove the couple alone from the fixed installation leaving all protecting tubes in place. If it is impossible to remove the iron tube from the couple use a similar tube in the fixed installation without the couple. Explore the temperature inside the protecting tube with an unprotected couple. If the temperature for several centimeters along the axis of the tube at the inner end is practically uniform, the depth of immersion is satisfactory. If, however, the temperature falls rapidly in this region the immersion is not deep enough. Second, the couple previously standardized is mounted complete in the fixed installation and compared with another checking couple mounted as previously discussed. The checking couple must have a small cross section and must be used either unprotected or protected by an extremely thin tube in order to minimize the loss of heat by conduction. The hot junctions of this couple and of the couple under test are brought closely together but not in contact. The checking couple should indicate a temperature more nearly that of the furnace than the temperature observed with the fixed couple. If the temperature difference between the two couples is large a greater depth of immersion should be employed. These methods are complicated by local variations in the temperature of the furnace but checks of this nature, although somewhat unsatisfactory, are better than no checks at all.

In an ordinary uncompensated thermocouple the

electromotive force developed depends upon the temperature of the cold junctions as well as upon the temperature of the hot junction. For some base-metal couples, having a linear relation between temperature and electromotive force, the electromotive force is proportional to the difference in temperatures of the hot and cold junctions. With such couples a change of 10 deg. C. in the temperature of the cold junctions, unless corrected for, would result in an error of 10 deg. C. in the temperatures indicated by the couples. Convenient methods for obtaining these corrections where the couple is used with the cold junctions at a temperature different from that for which it was calibrated are discussed in Bureau of Standards Scientific Paper No. 202. The following rules may be observed:

If a thermocouple has been calibrated with cold junctions at 0 deg. C. and is used with the cold junctions at t_0 deg. C. add to observed electromotive force the value of the electromotive force developed when the hot junction is at t_0 deg. C. and the cold junctions are at 0 deg. C. The original calibration then applies.

The corrections may be expressed in terms of degrees as follows: If a thermocouple has been calibrated with the cold junctions at 0 deg. C. and is used with the cold junctions at t_0 deg. C., add to the observed temperature the quantity $F \times t_0$ deg. C., where F is a factor depending upon the type of couple employed and upon the temperature of the hot junction. The value of F varies from 1.5 to 0.3 for base-metal couples but for rough work it may be assumed equal to 1.0. The correct values may be obtained by the method described in the paper referred to above. For a platinum, platinum-rhodium couple F has the values given in the following table:

Platinum, Platinum-Rhodium Couple. Calibrated at Cold Junction = 0°C.

Temperature of Hot Junction	F.
400°C.	0.61
800	0.54
1,200	0.47
1,400	0.45

A convenient method for applying these corrections is to set the indicator or galvanometer on open circuit to read the cold junction temperature. When this is done the above corrections are taken care of automatically, so long as the cold junctions remain at this temperature. Some types of indicators, especially the portable potentiometers, have a special adjusting dial for thus correcting for the cold junction temperatures. Bureau of Standards Scientific Paper No. 202 describes the method of correcting when the couple has been calibrated with a cold junction temperature of t_c deg. C. or t_f deg. F. and is used with a cold junction temperature of t_0 deg. C. or t_0 deg. F.

The importance of the control of the cold junction temperature is evident from the above discussion. Various devices are used to this purpose. The cold junction may be buried 8' or 10 ft. under ground at which depth the variations in temperature are scarcely ever more than 5 deg. C. throughout the year. The cold junctions may be maintained at 0 deg. C. by the use of ice boxes as discussed in a previous article (Apr. 1, 1918), although this method is not practical for a large industrial installation. Another method is to water-jacket the head of the couple allowing a small stream of water from the water main to flow through the jacket. Still another method in use is to lead wires of the same material as the couple from the couple to a cold junction box the temperature of which is thermostatically controlled. In all of these methods the couples are calibrated for the proper cold junction temperature.

In order to avoid the necessity of controlling the temperature of the cold junction near a furnace where the variations in room temperature are extreme, several methods of automatic compensation are in extensive use, such as balancing the decrease in electromotive force caused by an increase in the temperature of the cold junction by an external electromotive force from a battery. In this case an electrical circuit arranged in the form of a Wheatstone bridge is employed. Another method is the use, in the head of the couple, of a shunt and a series resistance, the latter having a zero temperature coefficient. Both of the methods give only partial compensation but by proper adjustment the compensation is accurate enough for most industrial work. The former method is usually effective over a much wider range of hot junction temperatures than the latter, which has its principal application for work in the neighborhood of the temperature for which it is arranged to give best compensation. In this temperature range the method is more desirable than the Wheatstone bridge method because no outside battery is required. Furthermore, in the latter method the degree of compensation depends upon the condition of the battery so that some attention is required to see that the battery is never run down.

A very simple method which is inexpensive, accurate, and convenient is the use of compensation lead wires from the couple to the indicator. Frequently the indicator or recorder is located in a room, at some distance from the furnace, where the temperature does not vary seriously. By means of the compensating leads the cold junction is moved from the head of the couple to this room and hence can be maintained at a fairly constant temperature. In the case of the base-metal couple the leads may be of the same material as the couple. The cost of platinum prevents such practice for rare-metal couples. However, inexpensive lead wires of copper and an alloy of copper-nickel are now available for use with the platinum, platinum-rhodium couple. Lead wires of this type have been tested at the Bureau of Standards and found to be very satisfactory, in fact the compensation is closer than 5 deg. C. for a variation in temperature of the couple-lead wire junctions of 200 deg. C. or more. Compensating lead wires for either base-metal or rare-metal couples may be carried from the couple to a cold junction box or to a pipe buried in the ground at some distance from the furnace. In this manner practically perfect control of the cold junction temperature is obtained.

Method of Making Thermocouple Junctions

The hot junction of a thermocouple should be made by soldering or fusing the two metals. Silver solder is useful at temperatures below 900 deg. C. or gold below 100 deg. C., but in general the best type of junction is made by fusion. The junction of a rare-metal couple may be made by use of a small oxygen illuminating-gas flame. Acetylene is not desirable. Special blast lamps suitable for this work are obtainable. The flame should be small, possibly 4 cm. long, the tip of

the lamp having an opening of from 0.5 to 1 mm. The junction should be fused into a ball about 1 mm. in diameter.

Another convenient method of fusing the junction is by use of an electric arc. One of the couple wires is connected to the positive terminal of the 110 volt d.c. main and the negative terminal is connected through a resistance to a graphite pencil having an insulating handle. The graphite should be about 5 or 6 mm. in diameter and should be sharpened to a point. For a couple of 0.6-mm. wire, a resistance of 30 to 40 ohms is used. Touch together the ends of the two wires of the couple and then bring the point of the graphite pencil into contact with the junction. As soon as an arc is formed draw the pencil away. With a little practice excellent joints can be made in this manner.

This method is also good for repairing broken couples. In this case the junction should be made as nearly as possible of the same size as the wire itself.

Large base-metal couples may be fused either by an electric arc or oxygen-gas torch. It is frequently the practice to twist the two wires as shown in Fig. 1 for a few turns as this possibly gives greater mechanical strength. Before fusing, the junction of the couple is coated thoroughly with borax. This is done by heating the ends of the two wires to a dull red heat and then dipping into the powdered borax. The borax adhering to the wire is then melted and the process continued until a heavy coating of the fused transparent borax is obtained. The couple may be mounted horizontally or suspended with the junction down. The arc or oxygen-gas flame is allowed to play upon the junction until the metal fuses into a neat bead. If sufficient borax is used the weld will show no signs of oxidation. The arc employed for this work is of the ordinary type consisting of two carbons, although for small couples the form of arc described above may be used.

No flux should be employed when fusing rare-metal couples.

Do not allow borax to come in contact with the porcelain lining of a furnace or with porcelain tubes. What borax remains on a base-metal couple may be removed if desired by dipping the junction while hot into water. The borax glass will then crack away. In making thermocouple junctions dark glasses should be worn in order that the work may be watched closely. It is also essential that the glasses absorb the ultra-violet light which may cause severe burns and injure the eyes. Special goggles for this type of work are advertised in the trade journals.

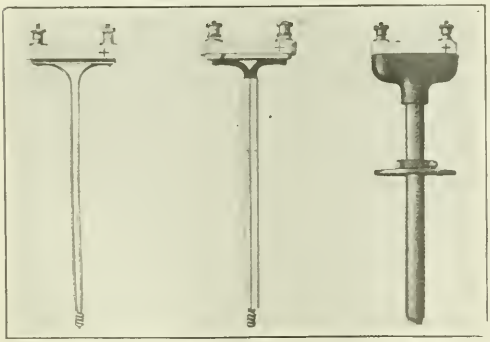

FIG. 1. TYPICAL FORM OF BASE METAL COUPLES. NOTE THE TWISTED WIRES AT WELDER JUNCTION.

Construction of Base-Metal Couples

A company using large numbers of base-metal couples can profitably construct them from wire furnished by the manufacturer instead of purchasing completely mounted thermocouples. For temperatures up to about 900 deg. C., iron versus constantan is suitable. For temperatures up to 1100 deg. C. special-patented alloys are obtainable such as chromel versus alumel. Wire for the construction of the above couples may be purchased in coils of various gages, (usually No. 6 or No. 8) and all couples made from any two coils will have very nearly the same calibration if special attention has been given by the manufacturer to the securing of homogeneous material. Wire for this purpose is advertised in the trade journals. To make a couple, cut off the desired length for each wire and fuse the junction as described above. The two wires are insulated by fire clay or porcelain insulating tubes and are then mounted in a steel or other type of protecting tube. For certain types of work thermocouple wire insulated with asbestos is useful. Wire may be procured insulated in this manner, or the insulation can be put on in the laboratory. There are two methods of doing this, one by the use of asbestos sleeving and the other by use of asbestos cord. Samples of these materials can be secured from dealers in asbestos goods. The cord is wound back and forth across the two wires in a figure 8. After the asbestos is in place it is good practice to fill the spacing between turns with a refractory cement such as ground alundum and water glass. Several pyrometer manufacturers sell cements already mixed for this purpose. Couples protected in this manner can be used for many processes without the outside iron protecting case.

Maintaining Laboratory Records

One of the most serious faults of an industrial laboratory is the failure to maintain satisfactory records. All calibration data, operation, costs, etc., should be recorded and filed for ready reference. Companies using several hundred or thousand couples per year should be able to state definitely whether iron-constantan couples will serve their purpose as well as the more expensive nickel-alloy couples. For any particular process, will the longer life of the more expensive base-metal couple justify its installation for temperatures around say 900 deg. C.? For operation at 1100 deg. C. will the longer life of the still more expensive platinum couple justify its installation? A couple which is used at temperatures high enough to seriously shorten its life is liable at any time to develop inhomogeneity affecting its calibration. Is this question of accuracy of sufficient importance for any particular process to justify equipping with more expensive couples? What is the life of the various couples used at different temperatures expressed in hours per dollar of cost?

Many types of protecting tubes for base-metal couples are available such as fire clay, carborundum, duriron, nichrome, and steel. What is the most economical tube to use reckoned on a basis of life in hours per

dollar? What depth of immersion gives the most satisfactory results for any particular type of installation?

Fused quartz or silica tubes for rare-metal couples do not break as easily as porcelain when subjected to changes in temperature. On the other hand, quartz is not very satisfactory above 1100 deg. C. Which type of protecting tube is found to be more satisfactory for any process in question? Is the factor of variable lead resistance and change in resistance of the couple upon deterioration of sufficient importance to justify a potentiometric installation for any particular process? What is the best method of checking couples in a certain fixed installation? What method is found by experience to be the most satisfactory for controlling the temperature of the cold junctions of the thermocouples?

Are they records made by the recorders, of real service, or are they simply filed away and no attempt made to correlate the data with properties of the finished product? Do the records show that the heating of the furnace has followed specifications and if not what is the best method of remedying this difficulty in the future? Should a method of automatic temperature control or signaling be adopted? Would a bonus system, awarding the furnace operator a certain increase in wages when the temperature of a furnace is maintained within prescribed limits, prove a profitable solution of the difficulty? Would an installation of optical pyrometers serve more satisfactorily than thermocouples for a certain process? Is the disadvantage that optical pyrometers cannot be made recording offset by a decrease in cost of maintenance of thermocouples at extreme temperatures? Would it be economical to hire a man whose sole work would be to observe, with an optical pyrometer, the temperatures of several furnaces? Or should a recording radiation pyrometer be employed?

Many of the above questions have been briefly considered in the present discussion but the most satisfactory answer to these and similar questions can be obtained from a systematic study of all records and data. The suggestions for efficiency should not be pushed to an extreme. It is better to err on the side of extravagance than economy in operating a pyrometer installation. The primary object should be to have a perfect working system of temperature control. However, expenses which the records show to be unnecessary should be curtailed.

Besides aiding in the establishment of an efficient system of temperature control the records are of extreme value for investigational work. In this field the pyrometer engineer must coöperate with the metallurgist and chemist. These latter, for example, find that the product which was heat treated on a certain date possesses certain properties which are especially valuable. It is desired to exactly duplicate the special heat treatment or to possibly alter the method slightly with the idea of producing still further improvements in the product. Investigational work of this character and even more specialized research may be carried on simultaneously with the routine work. The metallurgist, chemist, pyrometer engineer, and all concerned, including the operators of the furnace, will develop increased interest in their work because the spirit of research creates enthusiasm.

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Bibliography on the Physical Properties of Copper

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IN THE series of four articles on the physical properties of copper and the factors by which they are affected, completed in the last issue of *Metallurgical & Chemical Engineering*, reference was frequently made to original sources of information. Those sources are here presented as a bibliography of the subject. The segregation of references by topics will be found specially useful and convenient.

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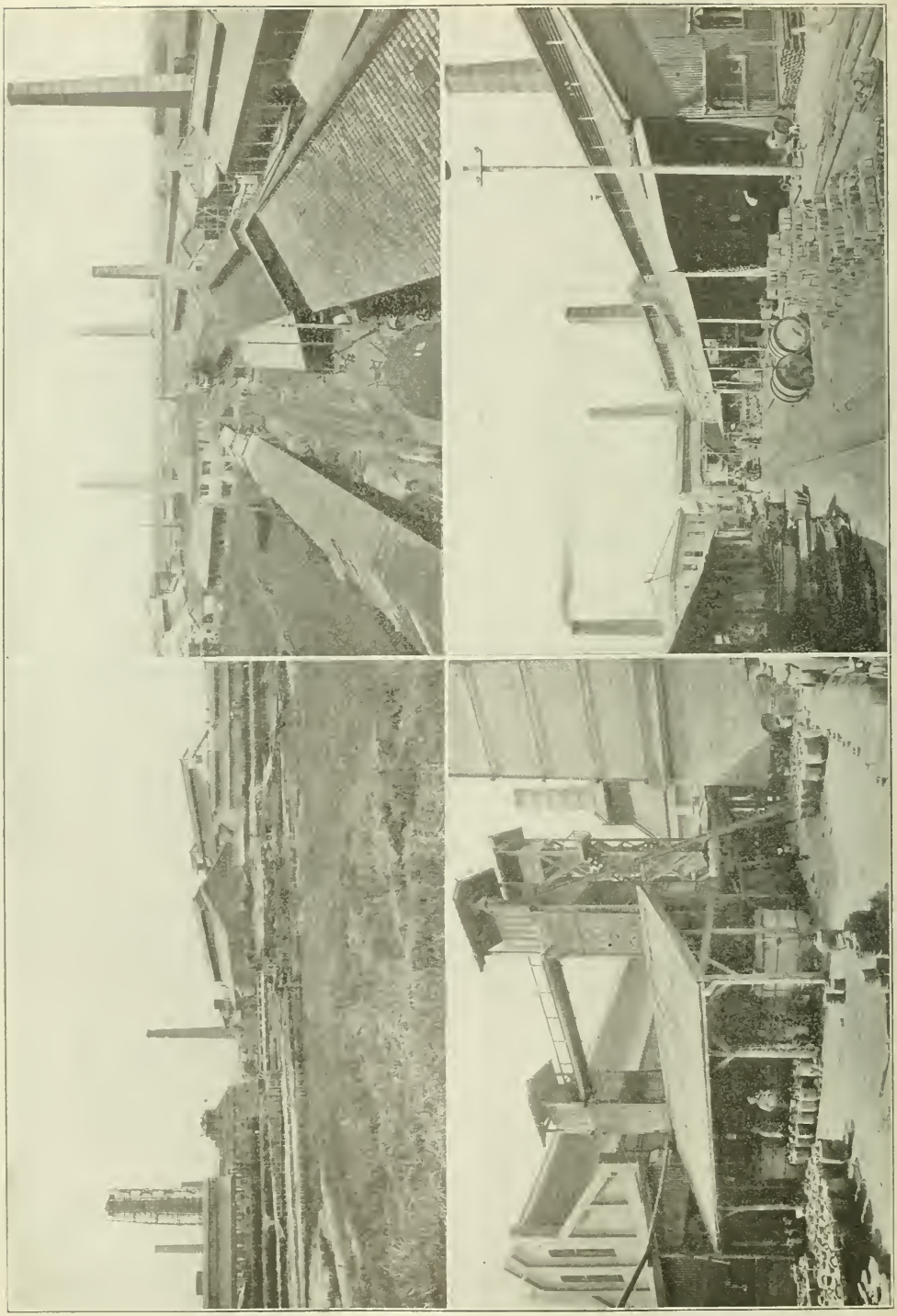

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Chemistry in Japan

DR. ALCAN HIRSCH of New York, consulting chemical engineer to the Japan Dyestuff Mfg. Co., Ltd., and consulting chemist to the pharmaceutical and drug establishment of the Sankyo Co., returned March 19th from Japan. In an interview with Dr. Hirsch by a member of our staff, he said that the coal-tar dyestuff industry in Japan was getting well established and flourishing. The Japan Dyestuff Co., which he serves, is that which was organized under government auspices in 1916, and is much the largest. The second in capacity is the Mitsui Co., which addresses itself to making anthracene products, and there are about ten other small concerns making a limited number of colors.

Among the products of the Japan Dyestuff concern are, as intermediates, aniline, phenol, naphthylamines, toluidines, nitrophenol, tolidine, methyl-anilines, naphthols, H-acid, dianisidine and Micheler's ketone. Among the colors produced on a commercial scale and on the market are benzo fast red A, congo red, benzo purpurine, methanyl yellow, chrysophenine yellow, Nippon direct black, Nissen dark blue, Nissen indigo (type), synthetic indigo, Nippon direct blue, Nissen black, methylene blue, methyl violet and rhodamine B. The Nissen colors are originals, developed in their own laboratories, and are especially designed for Far Eastern requirements. The company also refines its own crudes from by-product coke ovens and makes its own sulphuric acid, oleum, hydrochloric and nitric acids, electrolytic caustic soda and chlorine; and it has a concentrating plant for the recovery of sulphuric acid.

The plant is located at Osaka, on the Ajikawa River, which provides water communication with the Inland Sea and the Pacific Ocean. The crudes are all brought by water transportation. The company employs about 2,000 men. Mr. H. Nakaya is president, the present managing director is Dr. Miyoshi and the general superintendent is Mr. Sakai. Dr. K. Shimomura, the former managing director, resigned on account of ill health, but continues to devote a part of his time to the company in a consulting capacity.

The Mitsui Company confines itself to anthracene products and makes alizarine reds, blues and greens. The native dyestuff industry in Japan is somewhat similar to that in the United States. There is a shortage of cotton vat dyes, they seem to be ahead of us in anthracene products, and the synthetic indigo industry is growing. The prices range comparatively about the same in both countries.

The Sankyo Company makes chiefly pharmaceutical preparations and drugs and it will have a special interest for New York chemists in that Dr. Jokichi Takamine is president. Mr. M. Shiohara is managing director. This plant is located at Shinagawa, and operates the government subsidized pharmaceutical and drug establishment known as Naikoku in connection with its own works. They produce a large number of preparations, including phenol, phenolates and phenol derivatives, aniline, salicylic acid, salicylates (including sodium acetyl salicylate, phenyl salicylate, theobromine sodium salicylate, etc.), acetanilid, phenacetine, cocaine hydrochloride, salvarsan, neosalvarsan, formaldehyde, taka-diastase, chloral hydrate, tuberculin and still more, together with ointments, tablets, pills and compounded medicines.

Dr. Hirsch was full of enthusiasm over the National Exposition of Chemical Industries which was held at Uyeno Park, Tokio, from September to November inclusive, 1917. The government gave its official buildings for the purpose, to which a considerable number were added to provide room for the exhibits. Admission was ten sen (five cents) and all school children were taken

CHEMICAL PLANT OF SANKYO & COMPANY, FUJINAGAWA, TOKYO, JAPAN

to see it. A feature that impressed Dr. Hirsch emphatically was the way in which this exhibition brought chemistry home to the people at large. Artistically it was made very attractive and the uses of products were pictorially represented on back drops in booth structures and with wax mannikins. For instance, the Tokio Gaslight Company had a great pile of coal upon which stood a huge, many-armed-god of fire, fully fifteen feet high. Strands of red gauze were blown up from the coal underneath the figure, which gave an impression of flames. In the hand of each of the many arms was held a pictured plaque, indicating the uses of gas and coal products while ranged in front were many of the products themselves. The use of mannikins in the representations of the many industries gave a human touch to the show that made everyone feel that he understood at least something about it.

It is obvious that the Japanese are resolved to make their chemical industries permanent, and it is doubtful if any method could have been devised to make the people feel it to be a part of themselves more effectively than by their great exposition.

The Design and Operation of a Small Kjellin Furnace*

Manufacture of Electric Steel for Stamp-Mill Shoes and Dies on the Witwatersrand, South Africa

By GEORGE H. STANLEY and W. BUCHANAN

THE design of an induction furnace is very similar to that of a single-phase, core-type, alternating-current transformer, subject to the limitations of non-sandwiched windings and a horizontal position of the secondary. While it is most important with a transformer to generate a minimum of heat and circulate oil or water quickly to carry off the small amount necessarily generated, in a furnace the main object is to convert the maximum of the supplied energy into heat, and prevent its loss by the use of a non-conducting casing.

The action of a current in producing magnetism is of a reciprocal nature. Any change in the number of magnetic lines passing through a closed conducting loop produces an electric current in such circuit, the strength of which is directly proportional to the rate of change of the magnetism, and inversely to the impedance of the circuit. The relation for alternating currents corresponding to Ohm's law for direct currents is

$$E = I\sqrt{R^2 + \omega^2 L^2}$$

where E is the electromotive force,
I is the current produced in amperes,
R is the resistance of the circuit in ohms,
ω is the rate at which the current changes (or angular velocity),
L is the coefficient of self-induction of the circuit.

The coefficient of self-induction of the circuit may be otherwise thought of as the number of magnetic lines produced through a circuit when unit current flows through it.

Conductivity of Secondary

No very precise data appear to be published regarding the electrical resistance of different grades of steel at very high temperatures. It was therefore assumed that the temperature coefficient determined by Fleming and Dewar for pure iron at low temperature would give sufficiently accurate values for molten steel. This coefficient gives the resistance R at any temperature t deg. C., by the relation

$$R = R_0(1 + 0.00625\ t)$$

where R_0 is the resistance at zero Centigrade. The working temperature of the furnace was estimated to be about 1550 deg. C., so the resistance when hot appears to be 10.7 times the value at 0 deg. C.

There is even greater uncertainty regarding the value R_0 for high carbon steel, the resistance of which seems to vary from eight to twelve times that of copper. Ten times the resistance of copper was taken as likely to give an approximate average value, and the specific resistance of the heated metal figured to be $0.64 \times 10.7 \times 10^{-6}$ ohms per cubic inch. The circumference of the channel being 157 inches gives a resistance of 0.0107 ohms per square inch of cross-section. The minimum metal retained in the furnace between heats—900 lbs.—with about 22.5 sq. in. section has a resistance of 0.00048 ohms, while the maximum contents of 2900 lbs. with 72 sq. in. cross-section has a resistance of 0.00015 ohms.

Energy Required

Published data regarding the amount of energy required to melt one ton of steel in the electric furnace show a great deal of variation, depending upon the size and type of furnace. It seems to be the general opinion that the induction type takes rather more power than the corresponding arc furnace, and for the small size considered it appeared as if 900 kw.-hr. would be required per short ton to melt cold steel scrap. As, however, it was intended to pre-heat the scrap in the furnace attached to the mold-drying stove, it was expected that the actual expenditure of electricity per ton of product would be somewhat less than 900 kw.-hr., and the whole plant was designed to be able to give this amount. To supply 900 units every eight hours necessitates an average input of 112.5 kilowatts. Further, since this amount is not possible during the first hour or so when the small quantity of metal in the channel offers a maximum resistance, it becomes necessary to be able to give at least 120 kilowatts continuously with a full furnace. This energy is absorbed with $\sqrt{\frac{120{,}000}{0.00015}}$ or 28,300 amperes, the phase voltage required being

*The second instalment of a combined abstract of two papers: Electric Furnace Manufacture of Shoes and Dies on the Witwatersrand, by Geo. H. Stanley, *Jour.* Chem., Met. and Min. Soc. of S. Africa, Sept., 1917, and The First Electric Steel-Melting Furnace in South Africa, by W. Buchanan, *Jour.* S. African Inst. of Elec. Eng., Sept., 1917. This part of the papers relates to design. Features of operation were presented in the first article.

$28,300 \times 0.00015 = 4.24$ volts. It may be noted that unless the voltage be increased at light load, the energy supplied to the 900 pounds of metal would be 37.5 kilowatts, while it has been found that about 30 kilowatts at full temperature is lost by radiation.

Magnetic Field

One of the most serious drawbacks to the use of the induction type of furnace is its low power factor (down to 0.25) when used with current of the commonly available frequency of fifty alternations. The reason for this is the excessive amount of magnetic leakage caused by the necessary distance separating the primary from the secondary winding, thus demanding a large component of current at full load which absorbs no power, but simply produces a useless magnetic field.

To calculate the value of this leakage field accurately is practically impossible; but approximations can be made to give results near enough for the fairly close determination of transformer dimensions. The simplest result is obtained by considering the primary coil together with the secondary ring as being removed from the vicinity of the iron core and as equivalent to two parallel and concentric cylinders carrying current flowing in opposite directions; for which case Clerk-Maxwell has mathematically determined the value for the inductance L as

$$L = l\left(4 \ln \frac{d}{a} - 1\right)$$

where L is the inductance of the field,
l is the length of the cylinder in centimeters,
d is the distance between the cylinders,
a is the radius of a circle equivalent to the cross-section of the conductors.

In the case in point, l is the average circumference of primary and secondary, and is therefore $\frac{1}{2}\pi(50 + 22)$ or 112.5 inches, which equals 286 cm.; d is 14 inches and a is assumed to be 4 inches. Therefore

$$L = 286\left(4 \ln \frac{14}{4} + 1\right) = 1720$$

It will readily be seen, however, that the presence of the laminated core reduces the magnetic resistance of the primary leakage path by about one-third, and thus increasing the above value 10 per cent, giving L as 1892.

The value L was also determined by the more accurate but somewhat laborious method of determining the main leakage paths for both coils, the summation for unit current giving the leakage induction per turn.

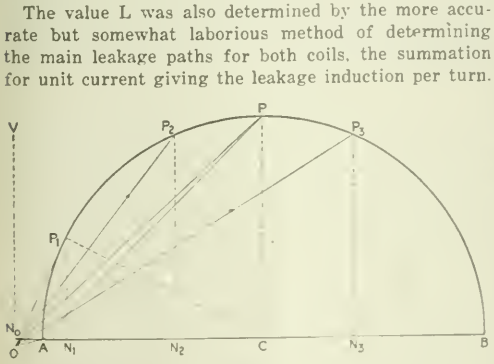


FIG. 1

In this procedure the dividing line of equal magnetic potential for primary and secondary is first calculated; then the mean length of path is determined for a small area, the flux through which can thus be obtained. The same process was repeated for all other sections. The value thus obtained for L was 1870, but since in any such summation the value cannot be too high, certain unobserved paths being left out, L = 1900 is taken as the most likely value. To bring L to henries, or practical units, the result has to be multiplied by 10^{-9}, thus the reactance is $2\pi \times 12.5 \times 1900 \times 10^{-9}$ which equals 0.00015 ohms. (12.5 is the number of cycles in the current to be supplied to the furnace.) This value happens to be exactly the same as the ohmic resistance, so that the tangent of the angle of lag between the resultant current and the applied voltage is unity, the angle is 45 degrees, and the power factor is cosine 45 deg. or 0.707. The magnetizing component of applied voltage with 28,300 amp. as before is 4.24 volts, and the resultant is $4.24\sqrt{2}$, or 6 volts.

In order to obtain the power factor of the primary circuit it is necessary to determine the magnetizing and power component of the open circuit current required by the laminated core. For this purpose a value of 6.3 volts per turn of primary winding is taken—5 per cent increase over the 6 volts computed above being allowed for overcoming the resistance of and forcing the magnetizing current through the primary coil. The magnetic flux passing round the rectangular core, and common to both primary and secondary coils, is given by the relation

$$\varphi = \frac{e \times 10^8}{4.44 \times f}$$

where φ is the magnetic flux,
e is the volts per turn in the primary winding,
f is the cycles of the current;

in our case,

$$\varphi = \frac{6.3 \times 10^8}{4.44 \times 12.5} = 11{,}300{,}000 \text{ lines}$$

on the usual assumption of a sine-shaped wave.

Open Circuit Current

The following tabulation shows the method of arriving at the open circuit current for a magnetic flux of 11,300,000 lines in the core:

Part of Core	Cross-Section, Sq. Cm.	Magnetic Density	Ampere-Turns, per Cm	Length of ϕ Path, Cm.	Ampere-Turns
Limb, inner	950	11,800	6.6	80	528
Limb, outer	950	11,800	6.6	80	528
Yoke, upper	1150	9,800	4.0	135	540
Yoke, lower	920	12,300	8.0	130	1040
Four joints	980	11,500	9200.0	0.1	920
Total					3556

Since the above magnetic density is the peak value, the ampere-turns are also the maximum. Assuming the current to be a sine wave, the peak is $\sqrt{2}$ times the effective value, and the latter is given by dividing 3556 by $\sqrt{2}$. Thus 2500 amp. is the magnetizing current if there were only one turn on the primary coil.

The loss due to hysteresis and eddy currents in the core, assuming the steel to be of good transformer quality, should not exceed 5 kw. at the magnetic density

and frequency stated above. The power component of open circuit current is thus $\frac{5000}{6.3}$, or 800 amp., and the total open circuit current is $\sqrt{(2500)^2+(800)^2}$ which equals 2620 amp.

The current on absolute short circuit with 6.3 applied volts (neglecting primary resistance) is $\frac{6.3}{0.00015}$, or 42,000 amp., the power factor being, of course, zero.

Other values for the relation of current to power factor may be obtained by calculation on varying the furnace resistance and assuming the inductance to be a constant. The latter assumption is very nearly true. Thus, when the furnace is one-quarter full of metal, the equivalent radius for the secondary is one-half that originally assumed. The mean value of a for the combination is then $\sqrt{\frac{16+4}{2}}$, or 3.16. Using this value in the formula instead of 4 gives L = 1820, instead of 1720 for full channel.

Instead of calculating all individual values of the power factor, it is very convenient and sufficiently accurate, with such a very leaky transformer, to use the circle diagram of the equivalent induction motor. This is shown in Fig. 8. In this diagram N_0A is the magnetizing component and N_0O is the power component, drawn to scale and to proper phase; therefore, OA represents the open circuit current to scale. The value of the absolute short circuit current is OB and the semicircle APB on AB gives the locus of the current in value and phase for any chosen voltage. Thus, for a secondary current represented by AP_2 the primary current is OP_2 $\frac{}{n}$ (where n is the number of turns in the primary winding); further, P_2N_2 represents the power component of the furnace current, and $P_2N_2 + N_0O$ divided by the length OP_2 gives the value of the primary power factor; that is, the power factor equals the cosine of the angle OP_2N_2 or the equal angle P_2OV. The highest power factor is at the point where this angle is a minimum: obviously given at point P_1 where OP_1 is a tangent to the circle. In our particular case, OP_1 is almost exactly 10,000 amp., and the power factor reaches 0.91.

Power Factor

The maximum true power consumed in the secondary is given at point P vertically above the center of the circle. This being equal to the radius, its value is ½ (42,000 — 2,500), or 19,750 amp. This value when multiplied by the applied voltage 6.3 gives 124 kw. The furnace current represented by AP is then $19{,}750 \times \sqrt{2}$, or practically 28,000 amp.; the corresponding primary current OP is 30,300 amp., and the primary power factor is $\frac{19{,}750 + 800}{30{,}300}$, or 0.675.

It will be clear from the diagram that any attempt to overload the furnace by adding metal, thus reducing the resistance of the secondary and increasing the primary current beyond about 30,000 amp. would result in less heat being obtained, although the generating plant would get hotter, owing to its giving a higher volt-ampere output. The two points P_1 and P_2 are chosen to illustrate this important feature. In both positions, the true power absorbed by the furnace is 113 kw., but, while this is obtained at P_2 with 23,500 amp. at 0.8 power factor, the same absorption at P_1 requires 35,500 amp. at only 0.53 power factor.

There can never be any advantage in working the furnace outside the limits defined by the first quadrant; in fact, it can seldom be economical to push the current even to within 10 per cent of the maximum power value when the loss and the heating of the generators are considered. When the input current is but 27,000 amp., the power available for heating is still 121 kw., or only 2.5 per cent from the maximum, but the power factor reaches 0.74. The exciting current required by the generators in this case would be considerably less than when giving 30,000 amp. at 0.68 power factor.

Pinch Effect

One consideration which forms a limit to the minimum amount of metal left after each cast is the pinch effect, which is due to the attractive force existing between parallel conductors carrying like currents. The secondary conductor, being fluid, is liable to be broken by such pressure. In the event of the cross-section not being absolutely uniform all around, the break occurs at the place of least cross-section, where the current density is greatest. This phenomenon has been investigated by Dr. Hering, who gives for an open rectangular channel, whose depth is twice its width, the critical current density as 895 $\sqrt{\frac{G}{H}}$ in amperes per square inch, G being the specific gravity of the molten metal, and H the depth of channel in inches. For example, in a channel 8 in. by 4 in. and G = 7, the critical current density is 835 amp. per sq. in. of original section, or a total of 26,800 amp.

Besides this internal stress there is a bodily force acting on the molten conductor, due to the repulsive effect from the unlike current of the primary. The magnitude of this force, with 30,000 amp. in conductors 14 in. apart, is 2.83 lb. per in. of circumference. With a full channel of 72-sq.-in. section, the same pressure would be produced if the molten metal revolved at a speed of about 14 revolutions per minute. The elevation of the outer edge when the metal is very fluid has no doubt given rise to the mistaken idea that the metal revolves bodily.

Primary Coil

The choice of a suitable primary winding was determined by the best output obtainable from the generators, and limited by the size of conductor available, which consisted of a finely stranded rectangular strip, having a net area of about 0.24 sq. in. With two conductors in parallel, a current of 600 amp. could be carried without undue heating, provided a moderate air circulation was available. The coil was wound, therefore, with 56 turns, a tap coming out at 45 turns connected to three terminals, so that changing from full coil to tap, or the reverse, could be carried out without loss of time. When working on full coil and a furnace

current of 28,000 amp., which corresponds to 30,300 amp. through a single-turn primary, the primary winding requires $\frac{30,300}{56}$ or 540 amp. at $6.3 \times 56 = 353$ volts.

If working on the tap, 670 amp. at 284 volts are necessary; some scope is thus provided for working the generators to the best advantage. The resistance of the coil at 200 deg. C. is 0.006 ohms; the loss at 540-amp. input is thus 1750 watts. The electrical efficiency, including 5000 watts core loss, is equal to the true power consumption in the secondary divided by the same figure increased by the core and ohmic losses in the primary. This amounts to $\frac{124}{124 + 1.75 + 5.0} = 95\%$ at maximum power. This is much higher than would be obtained with an induction motor for a similar output.

Pre-heating of Scrap

It has already been mentioned that normally the scrap steel is raised to a red heat in a coal-fired furnace before being fed into the electric furnace, and it will be obvious that where coal is reasonably cheap it must pay to pre-heat as much as possible and thus increase the output for a given supply of electricity. The limit to such pre-heating is fixed by the excessive oxidation of the steel at high temperature when exposed to direct action of the heated gases in the reverberatory furnace, although this may be prevented to a great extent by keeping a smoky or reducing flame over the metal.

It is given in textbooks that about 360 kw. hours of energy can heat and melt one ton (2000 lb.) of steel at about 1450 deg. C. if it could be applied without loss. The specific heat of cold steel is about 0.115, and it is usually assumed that it increases 1 per cent per 10 deg. C. at 1600 deg. C. it would, therefore, be about 0.3, so if the metal is heated, say, 200 deg. above its melting point, the added energy is 64 kw. hours per ton. If the metal is put into the furnace at, say, 480 deg. C. instead of at 30 deg., the average specific heat being 0.115×1.24 or 0.14, the energy saved is 65 kw. hours per ton, amounting to fully 15 per cent of the above 424 units.

It has been found in operation that a supply of 25 kw. to the furnace, in addition to the 5 kw. taken by the transformer, is sufficient to provide all loss by radiation and conduction with a furnace temperature of about 1600 deg. C.; but in actual working, owing to charging and testing, the energy required amounts to about 670 units per ton when casting about 2200 lb. every eight hours; being reduced to about 600 units when casting the same quantity of metal every six hours.

During August the energy supplied to the furnace was 58,656 kw. hours; there was produced 68.6 tons of net castings, the estimated metal melted being 76.3 tons, showing 770 units per ton melted. This energy included the amount required to dry and prepare three new furnace linings.

Frequency Converter

The current conversion is effected by a motor with a generator on each side directly coupled to give the required single-phase current, the armatures being connected in series. The only available generators were "inductor" alternators of a rather out-of-date type, and were converted from 25-cycle into 12.5-cycle machines by altering from six to three poles per side. When giving an output of 600 amp. at 320 volts, with a power factor of 0.68, the true power is 130 kw., the armature drop 14 volts, and the exciting energy for both generators 60 amp. at 75 volts. The output desired from the motor was 220 b.hp., this being required when the generators are giving 130 kw. with an estimated efficiency of 80 per cent; unfortunately, the only motor that could be obtained was one that had originally been built to give 820 b.hp., so that if used as it stood the efficiency would be poor and the power factor very low when working at about 220 hp. Fortunately, it was not very difficult to alter the stator winding from a rather inefficient parallel winding to one in which these windings were connected in two series. Although the motor must work with little rise in temperature, its efficiency is now probably 4 per cent lower than would be obtained with a motor designed to give, say, 250 hp.

Operating Tests

The following readings are taken from the running log. The actual value of the power factor at any particular load could only be obtained by using a power factor meter; but, instead, the volts, amperes and wattmeters are ready every half hour, which gives in practice sufficiently accurate results:

Full Primary Winding (56 Turns)			Primary on Tap, (45 Turns)		
Voltmeter	Ammeter	Wattmeter	Voltmeter	Ammeter	Wattmeter
296	300	240	310	402	18
316	312	282	300	392	66
316	320	318	296	418	120
312	322	360	290	438	168
306	318	408	275	470	222
310	319	450	275	480	276
			265	498	330
Av. 310	315		258	516	378
Kva., 97.65			250	540	432
Kw., 84			253	555	480
Power factor, 86%					

In the second case, the watt reading shows a nearly constant difference, so the average kw. is 103. Considering this to be constant, which it appears very nearly to have been, the average kv.-a. over each hour is 120 at 400 amp., 124 at 438 amp., 131 at 483 amp., 134 at 516 amp., and for the last half-hour 138 at 549 amp., the corresponding values of the power factor are 0.86, 0.83, 0.79, 0.77, 0.75; the latter is the value for the equivalent of $549 \times 45 = 24,700$ amp. in primary for a single turn winding.

During the month of January, 1917, the furnace meter registered 44,940 electrical units, while the meter at the transformer substation showed 71,800, giving an overall efficiency of 62.6 per cent. For August, the furnace received 58,656 units, and the substation meter registered 89,700, giving on the greater average output an efficiency of 65.5 per cent.

Operating Costs

Working costs are somewhat high on account of the small scale of the operations, labor in particular being a very big item. In fact, the same number of hands could probably turn out two or three times the present output with a larger furnace. Three eight-hour shifts are worked, and each of these requires an electrician in charge of the electrical plant and a furnaceman or molder in charge of the furnace. For this latter it has

been difficult to secure suitable white workmen, and colored labor is employed, therefore, on some shifts under supervision of the electrician. Consequently, the number of white furnacemen on the pay roll varies between one and three. The actual furnace charging is done by "Cape boys," of whom five or six are employed in all, and about fifteen natives are used in breaking up scrap and miscellaneous labor. All are under the charge of a works manager, so that the wages bill and supervision fees amount to about £400 ($1940) per month. Electric power is the next big item, and amounts to close on £200 ($970) per month, and the cost of scrap at £1 ($4.85) per ton is third in order of magnitude.

The largest output so far was obtained in July, 1917, when 73 tons of castings were produced at a works cost of less than £14 ($67.90) per ton. In August nearly 69 tons were made, so it is quite safe to assume an average output of 60 tons per month. For this the costs would be approximately as follows:

Scrap, 70 tons, @ £1	£70	$339.50
Pig iron, 1½ tons, @ £20	30	145.50
Aluminum, 30 lb., @ 2/-	3	14.55
Magnesite (calcined), 2 tons, @ £18	36	174.60
Miscellaneous stores	15	72.75
Repairs and renewals	5	24.25
Tools, etc	200	970.00
Electric power	30	145.50
Cartage	20	97.00
Miscellaneous sundries	400	1940.00
Salaries, wages, and supervision fees	£824	$3996.40
Per ton nearly	14	66.50

Economic Considerations

In concluding this account it may not be out of place to call attention to the exceptional opportunity offered by present conditions and prices to make a serious commencement with the iron and steel industry.

Apart from the plant described, small as it is, there are only two other concerns turning out such steel in any quantity. Both work only on scrap, and only one of these has melting furnaces, the other merely reheating and rolling. Both together are quite inadequate to supply the local demand if importation from oversea became impossible. Further, the supply of suitable scrap though large is not unlimited, and in some directions there is an actual shortage of raw material already. So in this direction also the country is likely to be thrown on its own resources before long.

From the point of view of the various iron foundries also, the position is much more serious and must give rise to careful consideration of the possibility of local production. Pig iron of first quality at present approximates in price to £25 ($121.25) per ton, while the prewar price was about £9 ($43.65). At first sight even the latter figure seems attractive enough to encourage local production, but it must be remembered that the whole South African consumption—as pig—is comparatively small and a large output would only be disposable in the form of steel. Even as cast iron, however, the present requirement is enormously greater than before the war; much casting work is being done for the mines and other consumers which formerly was imported, and if only the iron were available at reasonable price, a large industry could be created in the manufacture of pipes and other agricultural machinery. But a very much greater tonnage could be absorbed in the form of steel, and without attempting to cater to all the large and varied requirements now imported, comparatively simple products could be made.

Synopsis of Recent Metallurgical and Chemical Literature

Potash from Blast Furnace Gas.—Two papers read before the Cleveland Institution of Engineers (England) and published in *The Iron and Coal Trades Review*, Jan. 18, 1918, deal especially with cleaning blast furnace gas and the recovery of potash. The first paper, by A. Lennox Leigh, described an installation of a gas-cleaning plant at the North Lincolnshire Iron Company's works. Savings were effected on boilers and stoves by the use of cleaned gas. The author states that so far as a general statement for all furnace plants can be made of the consumption of gas under different conditions, the cleaning of all the gas and its use for boilers and stoves shows a better result than cleaning a portion and using this in the blowing and power gas engines required for the furnace, when taking into account the other economies, the increased value of the cleaned gas and the extra capital outlay for a gas-engine installation. To indicate this the following approximate gas distribution can be compared; it will be noted in the figures given, the reduction of the amount of cleaned gas used for boilers is taken as 25 per cent, not 50 per cent; the reason for this is because the evaporation with uncleaned gas in the plant mentioned is probably lower than in most districts, and an attempt is made to give as general a comparison as possible; any of the figures may have to be decreased or increased for particular circumstances, but to make the comparison of more value it ought to be as near as is possible with average conditions:—(1) Uncleaned gas with boilers and steam engines; (2) cleaned gas with boilers and steam engines; (3) part of gas cleaned for the blowing and power gas engines required for the furnace; (4) cleaned gas with blowing and power gas engines.

	1 Per Cent	2 Per Cent	3 Per Cent	4 Per Cent
Stoves	40	30	40	30
Blowing and power	40	30	15	15
Loss	10	10	10	10
Total required	90	70	65	55
Uncleaned spare gas	10	..	35	..
Cleaned spare gas	..	30	..	45
	100	100	100	100

The author's summary of advantages is as follows:

(1) Economy in gas for boilers.

(2) Economy in gas for stoves.

(3) Fewer stoves required and probably fewer boilers.

(4) Better control of furnace operations and saving in cleaning stoves, boiler flues, etc.

(5) Additional source of income from the larger volume of spare gas of an increased value for the production of cheap power and coal economy.

(6) Recovery of potash as a by-product.

The second paper, by Kenneth M. Chance, dealt with the commercial aspects of the situation. He said with the present rate of pig iron production in England it may be safely estimated that not less than 200,000 tons of potash are being fed into the blast furnaces each year. Of this, in round figures, three-quarters (or 150,000 tons) passes through the furnaces and away in the slags in insoluble form, and one-quarter

(or 50,000 tons) is volatilized and carried from the furnaces in the gas in the form of carbonate, chloride or cyanide, usually a mixture of all three. Of this 50,000 tons, a small proportion is carried down into the dust catchers and down-comers with the heavy dust, and another small proportion is recovered from the stoves and boiler flues, after the combustion of the gas, in the form of sulphate of potash, into which it has been converted during the process of combustion. The remainder, which may be estimated as being in the neighborhood of four-fifths of this 50,000 tons, escapes with the gas up the chimneys and is liberated into the atmosphere. Of all the potash charged into the furnaces, therefore, at the present time, not more than 5 per cent is recovered, and of that 5 per cent quite a considerable proportion is thrown away with the heavy dust as having no value. The British Cyanides Company, Ltd., and the North Lincolnshire Iron Company have carried out a long series of experiments on a practical scale and have devised two methods of recovery. One process aimed to volatize the potash from the furnace, as carbonate is not recommended as a commercial method. A simpler and more economical method of recovering the potash charged into a furnace manufacturing ordinary pig-iron is by adding to the charge an alkaline chloride, of which common salt is the one most readily available. This has the effect of converting the silicates of potash into chlorides, which are volatilized at ordinary working temperatures into the gas in that form, substituting soda for potash in the slags, and there is ample evidence to show that, generally speaking, this method can be relied upon to render available for recovery from 70 per cent to 80 per cent of the potash charged into the furnace in contrast to the bare 5 per cent now recovered.

The author stated that a company has been formed entitled the British Potash Company, Ltd., the shareholders in which are the two firms mentioned, John Lysacht, Ltd., and the government. In the constitution of this company particular attention has been paid to the importance of insuring that its financial strength shall be sufficient to establish a national potash industry capable of holding its own against external competition, and, until this has been secured, dividends upon the share capital are limited to 6 per cent per annum. The whole of the knowledge and experience gained by these firms, together with their inventions relating to the recovery of potash, have been placed at the disposal of the potash company in consideration of the right to subscribe at par for half the shares in that company, and no firm or individual has either asked or received any other consideration of any sort or kind whatever for money expended or services rendered up to the formation of this company. The remaining half of the shares have been taken at par by the government. The shares owned by the private interests, after provision has been made for ample reserves, are to receive by way of dividend out of profits a certain fixed sum per ton of potash produced each year, and the balance of the profits made by the company will be distributed as dividend on the government shares. The proposition which the company lays before the potential suppliers of raw material is that, subject to such arrangements as to detail as will insure the raw material being supplied in such a form that the potash can be economically recovered from it, their raw material shall be purchased by the potash company at a price which will insure them an immediate profit per ton of potash contained in it which is identical to the profit per ton payable by way of dividend on the shares in the potash company subscribed by the private interests. These dividends on the privately owned shares can only be paid out of profits earned subsequent to the establishment of these large reserves, whereas the profit to the suppliers of the raw material is part of the purchase price of that material. That sum in the case of chloride of potash is 25s. per ton, and is equivalent to a potential profit of from 4½d. to 9d. per ton of pig iron.

This is a figure of profit on a by-product of the manufacture of pig-iron and not the purchase price of that by-product, but it is obvious that no company can guarantee a profit on the raw material which it purchases unless it can make a profit on the finished commodity that it has to sell, and therefore, just as in the case of the potash company, this profit of 25s. per ton to the privately owned shares varies upwards and downwards to a certain extent as the cost of production decreases and increases, so arrangements will have to be made with those who supply the raw material that there shall be variation upwards and downwards of this figure of 25s. per ton according to the effect which the form in which this raw material is produced has upon the cost of manufacture of the finished product. Under this arrangement, the state is in a position to insure that the most rigid economy in manufacturing is inforced, and, as their success will depend entirely upon their obtaining ample supplies of suitable raw material at low prices, the potash company will be bound to train and maintain a staff of skilled engineers and research chemists whose duty it will be to assist the suppliers of the raw material to produce the maximum quantity at the minimum cost and to keep their plants running at the greatest possible efficiency. As also the cost of transit from the source of supply to the central factories will be a large item in the cost of manufacture, the potash company will erect a central factory in each district which will undertake to supply sufficient raw material to keep that factory in full operation. After careful consideration it has been determined that the smallest unit consistent with economy is a factory whose output will be not less than 25,000 tons of chloride of potash per annum. The first of these factories has been erected at Oldbury, and is in a position to commence manufacturing operations, and it is the hope and belief of those whom, as managing director of the potash company the author represents, that the company shall be compelled to erect three or four similar factories in other districts, the most important of which is obviously Cleveland. The development of this industry will be watched with interest

Pyrometry

Calibration of Optical Pyrometers.—Wien's distribution law has been universally used in the interpretation and extrapolation of experimental results in the calibration of optical pyrometers such as the Le Chatelier, Wanner, Morse, Holborn and Kurlbaum pyrometers, or the Shore pyroscope which measure temperature by measuring the intensity of radiation of a definite wave

length emitted from a theoretical black body. This law is stated as follows:

$$\circ(\lambda, \theta) = \frac{Ce^{-\frac{c}{\lambda\theta}}}{\theta^5}$$

where $\circ(\lambda, \theta)\ d\lambda$ is the intensity of radiation of a black body at absolute temperature θ produced by waves of length between λ and $\lambda + \delta\lambda$ and C and c are constants. F. E. Wood criticizes this formulation in the *Philosophical Magazine*. Vol. 35, page 190 (Feb. 1918, from a mathematical point of view, and shows it to be inconsistent with other results following from Wien's assumptions. He derives a new law, which is shown to be consistent with correlated formulae as follows (notation as before):

$$\circ(\lambda, \theta) = \frac{Ce^{-\frac{c}{\lambda\theta}}}{\lambda^5}$$

Iron and Steel

Metallurgical Treatment of High Speed Steel—J. L. Thorne recently presented a paper before the Steel Treating Research Society in Detroit, giving considerable information on this subject. He warns the purchaser from buying steels by trade name only, since there have been instances where the composition has been materially changed without notice to the user. The high speed steels on the market now are comprised within the following limits, a third column giving a good chemical specification.

	Range	Proposed
Carbon	0.47 to 0.91%	0.65%
Silicon	0.12 to 5.00	0.12
Manganese	0.12 to 0.67	0.25
Sulphur	0.008 to 0.057	0.02
Phosphorus	0.006 to 0.051	0.02
Chromium	1.50 to 5.52	3.5
Vanadium	0.13 to 2.5	1.0
Tungsten	11.74 to 22.27	18.0

As the steel is purchased it is sampled and analysed. Close adherence to chemical specification is impossible and undesirable. Sulphur and phosphorus should be kept low; manganese as low as necessary to inspire against harmful sulphur effects, and silicon low to prevent brittle silicide segregations. The tungsten-chromium-carbon combination is of course responsible for the "red-hardness"; while vanadium, originally added merely as a scavenger, increases the elastic limit and the resistance to wear and shock. New high-speed stock should have a hardness slightly under Brinell 250 or scleroscope 35 in order that it may be machined readily. Microscopic examination is also undertaken before the material is accepted, looking particularly for forging cracks, surface decarbonization, uniform structure, segregation and ingotism.

After the tool has been formed and sent to the hardening room, it should first be given a "soaking" heat at from 1500 to 1800 deg. F. to avoid expansion strains and cracks if suddenly put into the high hardening heat. When uniformly heated, it is transferred to a high-temperature furnace, whose heat is as uniform as possible, controlled with standardized pyrometers, and allowed to remain there a certain specified time. This time is automatically registered by colored lights and warning buzzers, so that at the proper instant the tool can be removed and quenched—preferably in oil, circulated over cooling coils to maintain a uniformly low temperature. Taylor discovered that to get the maximum red-hardness this quenching temperature must be far above the critical temperature—approaching that where the tool actually softens. This hardened tool is then "drawn" in a low temperature furnace—bearing in mind that the metal progressively softens up to a point lying between 700 and 800 deg. Fahr., from which to about 1100 deg. it increases in hardness with the temperature.

In a very extensive test of nearly a thousand drills made of all available domestic and foreign high-speed steels, it was discovered that the most efficient tools exhibited a great resemblance in microscopic structure, regardless of their manufacture or heat treatment. This has led to the adoption of the so-called "standard structure" to be looked for in experimenting to discover the proper heat treatment to give a new lot of metal. Start with several samples and subject them to various temperatures for various times approximating the expected conditions; a microscopic examination will then show that one which nearest approached the standard structure. As the temperature and time of this piece is known, proceed to another set treated at temperatures and times slightly above and below the first approximation. In this way, the third series will give the exact heat treatment which will produce the desired structure. Finished tools are then run on an experimental drill press, and their work compared to that done by one of a set of control tools, and reported as so much plus or minus standard.

Malleable Cast Iron.—In a discussion of the necessary characteristics of successful production of "white-heart" castings, Mr. E. Adamson, in a paper read before the Staffordshire Iron and Steel Institute, Jan. 12, 1918, presented an interesting tabulation of the role played by the chemical composition, reproduced below:

	Si	S	Mn	Total Carbon
Separation of graphite or free carbon is *induced* at a temperature which is lower	the higher the Si	the lower the S	the lower the Mn	the higher the total carbon
The rate of separation of graphitic carbon is less the lower the temperature and	the lower the Si	the higher the S	the higher the Mn	the lower the total carbon
Combined carbon corresponding to equilibrium at a given temperature dimishes with	increasing Si	lower S	lower Mn	higher total carbon

The author remarks that it is important to note that the separation of graphitic carbon once induced will continue at lower temperatures and that graphitic carbon begins to form in the molten iron. Hot metal, for a white iron casting, must therefore be retained in the ladle a minimum time, and annealed carefully to prevent rapid precipitation of free carbon.

The facts noted in the column headed silicon were published in 1902 by Charpy and Grenet, and are understood well enough to require no further comment. The total carbon rarely amounts to less than 3 per cent; 2.75 per cent is hard to anneal, but will be harder and stronger after a longer annealing at higher temperature. While it is possible to get good "white-heart" castings with sulphur as high as 0.25 per cent, the margin of safety in annealing is much greater if sulphur is much lower, say, 0.05 per cent. A high sulphur, under-annealed casting is brittle, over annealed it will exfoliate. Manganese is not capable of masking the ill effects of sulphur, oft-repeated statements to the contrary. Phosphorus is quite safe up to 0.25 per cent.

Recent Metallurgical and Chemical Patents

Production of Metallic Nitrogen Compounds.—MATHIAS SEM, of Christiania, Norway, proposes to produce cyanamids by introducing a carbide in the form of dust, together with nitrogen into a reaction chamber. The nitrogen as well as the carbide should be preheated to about 700-800 deg. C., and before the process is started the brickwork of the furnace is also heated up. The exothermic character of the process is utilized to maintain the necessary temperature in the furnace and partly to bring about a very rapid nitrification. (1,256,935, Feb. 19, 1918).

Cyanides and Ammonia.—PAUL A. STARKE of Berkeley, Cal., patents the production of cyanides from natural gas and ammonia in the presence of a catalyzer of sodium carbonate, magnesium oxide and iron. The gases are passed through the reactive substance in a retort heated to 1,000 deg. C. The cyanides formed are recovered by lixiviation and crystalization. (1,256,272, Feb. 12. 1918). In another patent the same process is used to produce ammonia from natural gas and air. In this case a high pressure is used and a temperature of from 400 to 800 deg. C. The ammonia is absorbed as sulphate or liquefied. (1,256,273, Feb. 12, 1918).

Miscellaneous Chemical Process and Products

Sulphuric Acid and Salt Cake from Niter Cake.—A method of decomposing niter cake incidental to sulphuric acid manufacture is patented by LAURENCE T. SHERWOOD, of Connellsville, Pa. By this process the heat of combustion of the sulphur or pyrites is utilized by a simple apparatus for the decomposition of the niter cake and the decomposition of the niter cake furnishes sulphur-oxides which are used along with the sulphur-oxides of combustion in the manufacture of sulphuric acid; thus an economy of fuel is affected. (1,255,474, Feb. 5, 1918).

Electrical Insulating Compound.—WILLIAM T. CUSHING of Milwaukee, Wis., patents an electrical insulating compound, the patent being assigned to the Cutler-Hammer Mfg. Co., of Milwaukee. The composition comprises asbestos and a binder including a varnish of East India gum, China wood oil and rosin and an oxidation retarder of stearin pitch and coal tar pitch in the proportion of approximately two parts of the former to one part of the latter. (1,255,139, Feb. 5, 1918).

Purifying Barium Sulphide.—W. E. PRISK and H. R. HARRISON of Halifax, Nova Scotia, patent a method of purifying barium sulphide by arranging the apparatus so that the solution is passed alternately through a plurality of filters, containing manganese dioxide and calcium carbonate, alternately, the solution being subject to the action first of one of these materials, and then of the other, and the process being continued until all of the impurities are removed. After the solution is thus purified, it may be used for the preparation of insoluble salts of barium, such as barium sulphate, and these salts may be used commercially as desired. (1,256,593, Feb. 19, 1918).

Manufacture of Ammonium Nitrate.—REIDAR BLOM, of Rjukan, Norway, describes a process of making highly concentrated solution of ammonium nitrate or even this salt in the solid state directly by means of the dilute acid. The process is based upon the observation that solutions of ammonium nitrate are excellent absorbents for ammonia gas. Therefore the dilute solutions of ammonium nitrate obtained by neutralizing ammonia water with dilute nitric acid or in any other way may be used for absorption of ammonia gas, and the ammoniacal solution so obtained is neutralized with dilute nitric acid. By repeating at will these operations of absorption and neutralization it is possible to obtain saturated solutions of ammonium nitrate or a precipitation of the solid salt respectively the cost of evaporation thus being reduced to quite a minimum or even totally eliminated. (1,256,513, Feb. 19, 1918).

Refractory Material.—HANS M. OLSON, of Lompoc, California, patents a heat-insulating composition consisting of infusorial earth in a finely divided state, and a binder of sodium sulphate, aluminum sulphate and lime, the infusorial earth being from 75 per cent to 95 per cent of the entire mass, and the binder from 5 per cent to 25 per cent. (1,257,922, Feb. 26, 1918).

Hydrocarbon Coke.—R. P. PERRY, of Montclair, N. J., patents a process of coking coal-tar pitch and similar liquid materials by heating the material in liquid form in comparatively thin films on a moving surface. The patent is assigned to the Barrett Co. of New York City. The process is equally applicable to the residue from petroleum refining which is usually coked by continued high heating in the stills, thereby greatly shortening their lasting qualities. The apparatus patented is similar to a film dryer and delivers coke continuously by a hot cylinder rotating in a liquid bath, catching up some of this liquid, coking same and delivering it to a bin during the rotation. (1,257,959, Feb. 26, 1918).

Electrolytic Processes

Electrolysis of Foul Copper Sulphate.—F. L. ANTISELL of Perth Amboy, N. J., utilizes the following equipment for the electrolysis of copper sulphate solutions containing large amounts of such impurities as iron salts: A rectangular tank with cathodes suspended near either side, the tank itself having filling and drain pipes. Supported within the tank and between the cathodes is a smaller rectangular container containing granular gas-house carbon, and provided with independent filling and drain pipes. The sides of the container may be of rotary cut wood veneer, in case the container is to act as a diaphragm; otherwise it may be latticed or consist of wire netting. The granular carbon acts as the anode, being energized by carbon rods immersed in the container.

Using the wood diaphragm, a good deposition of copper may be had from solutions containing as low as ½ per cent copper, and at the same time increase the acid content of the solution by the use of H_2SO_4 as a depolarizer and circulating same through the anode. The cathalyte is also circulated. The voltage is reduced for several reasons. One is that the numerous points of the crushed carbon present areas of low-surface tension as well as a greatly increased surface of collection where the oxygen is easily liberated, thus reducing the

resistance between terminals. The veneer separates the anolyte from the catholyte sufficiently so that any ferrous iron in the solution will act as a depolarizer, and ferric iron cannot migrate to the cathode with correspondent reduction of current efficiency.

In case a perforated container is used, the solution to be electrolyzed is entered through the crushed carbon and drained from the outer tank. This permits a very high anodic efficiency, which is often as low as 5 or 6 per cent when depolarizing with SO_2 gas, but which attains 80 per cent in this method, with consequent decrease in voltage. The voltage of a tank using an insoluble lead anode after being in service a short time is about 1.20 volts at the anode. In addition to this is an ohmic resistance of about ½ volt (when operating at a current density of 16 amp. per sq. ft.), due to the lead oxide which rapidly forms on the anode. The counter electromotive force of the carbon anode is about 0.35 volt, at which plating begins. At 10 amp. per sq. ft. the voltage increases to 1.30, and the ampere efficiency is maintained at nearly 100 per cent. The power input is, therefore, materially lowered.

In electrolzing leach solutions containing copper and iron, it is usual to continue the electrolysis only as far as the time where the ampere efficiency drops below 80 per cent, when the balance of the copper is precipitated upon iron, at the expense of the iron, sulphuric acid, and large labor cost. With the present cell, it is claimed that solutions containing as high as 50 grams of iron per liter have been successfully electrolized. (1,239,443, Sept. 11, 1917.)

Aurocyanide Electrolysis.—U. C. TAINTON of Johannesburg, Transvaal, proposes to recover gold and silver from cyanide solutions with high base metal or low free cyanide content by the aid of an electrolytic cell illustrated in Fig. 1, having as rotating cathodes 13 a disk of wire mesh, or a thin sheet with serrated arms cut in it designed to pick up and hold metallic threads which may be introduced with the solution. The anodes 19 are of lead, encased in a non-conducting rim and porous diaphragm 22, to prevent the anode products from mixing with the catholyte and causing resolution of the precipitated metal. The anode compartments may also be partly filled with alkaline sulphate solution to prevent disintegration of the metal, and are provided with vent pipes 20 for the escape of gases generated. The rich solution enters the casing through pipe 32, and part of the metal is precipitated in the meshes of the first rotating anode as it passes through. High current density and rapid rotation will cause the incoherent deposit to become detached and carried along with the electrolyte through successive openings in the anode compartments and whirling cathodes until the solution carrying substantially all the values as finely divided metallics is drawn off through pipe 33 and settled or filtered as desired. (1,251,302, Dec. 25, 1917.)

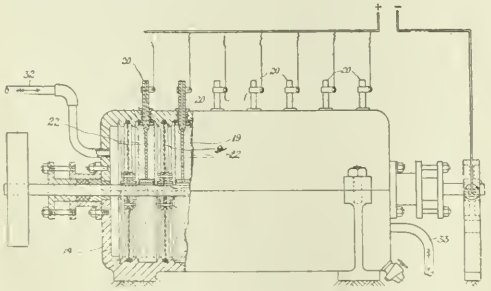


FIG. 1. ELECTROLYTIC CELL FOR CYANIDE SOLUTIONS

Nickel-Copper Separation. — GEORGE A. GUESS of Oakville, Ontario, patents a process of separating nickel from copper by the electrolysis of nickel-copper anodes in an electrolyte of nickel sulphate containing an insoluble reagent, such as alkaline earth carbonate of hydrates, preferably limestone. The reagent is kept out of contact with the cathode by means of a porous diaphragm. As the nickel and copper sulphates form at the anode, the copper sulphate is precipitated on the limestone, forming insoluble copper carbonate and calcium sulphate, while the nickel migrates to the cathode and is plated out of solution. (1,251,511, Jan. 1, 1918.)

Filter-Press Electrolyzer.—H. T. SHRIVER of West Orange, N. J., has patented improvements to the leaves of the ordinary filter-press type electrolyzer, Fig. 2, commonly used in the production of oxygen and hydrogen from water. He casts gas chambers above each plate, into which the liberated gas enters through ports 22, and from which they escape over the top of the partition 21 into continuous ducts 13 or 14, and thence to separate tanks for their reception. In this manner the electrolyte is entirely absent from the gas ducts, preventing the customary short circuiting and loss of efficiency due to this cause, since the pressure on the electrolyte is such as to keep its level continuously below the tops of the partitions 21. The supply of pure water necessary to replace that electrolyzed is introduced through the continuous ducts 29 and 30, from which it enters each section as needed through grooves 31 and 32 cast in the side of the leaves. The water enters the bottom of the section, and diffuses upward through the denser electrolyte, each section being automatically kept at the proper density and elevation by maintaining a proper pressure on the fresh water supply. (1,239,530, Sept. 11, 1917.)

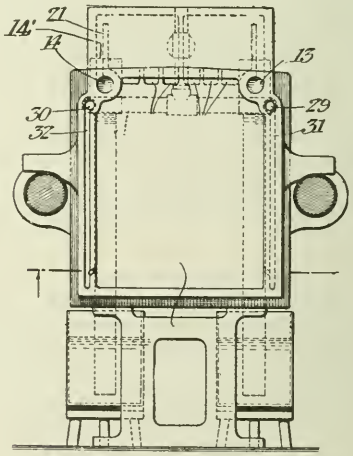


FIG. 2. OXYGEN AND HYDROGEN GENERATOR

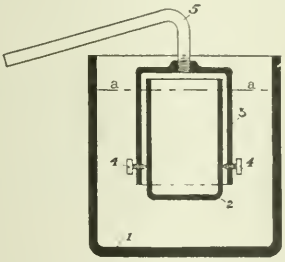
A New Experimental Retort for Dry Distillation

By F. E. Coombs

DURING the course of a long series of dry distillations it became desirable to control the temperature in varying limits, and to have means for easily and quickly opening, cleaning and closing the retort, while still hot. Nothing of this nature being available in stock apparatus the form described in this article was devised and used successfully.

The accompanying illustration shows clearly the construction of the retort and vessel for holding a bath of suitable fused heating means. The original apparatus was put together from ordinary iron pipe and fittings and worked satisfactorily. It is, of course, a better plan to make this outfit from pattern as a casting, for which either iron, brass, aluminium or any other preferred material may be used, according to circumstances.

The drawing shows, 1, an iron vessel to hold melted lead, sulphur or caustic soda, according to the temperature range required. This vessel is conveniently supported and heated and a thermometer dipped into the bath for control of heating.



CROSS SECTION OF RETORT FOR DRY DISTILLATION

A container, 2, with a very loosely fitting cover, 3, is filled with the assay and immersed to a point where the level of the fused bath (a) will be safely below the top of the container; the cover is firmly fixed to the container by means of three screws, 4, so that there is an approximately even space of about ¼ inch between cover and container, serving as a seal-channel, which may be made as deep as the conditions of the work demand. That is to say, if a distillation only is required and the internal pressure is not to be much above the atmosphere, both container and cover may be fairly shallow; but if gases are to be collected, or the vapors forced against material resistance in the way of absorbers, etc., then proportionate depth of seal must be provided in designing the container and cover.

A gooseneck, 5, is screwed into the top of the cover, and in the case of small apparatus this will be used as a handle and is held in the usual ringstand clamp when in use in the bath.

A section of 4-in. pipe 7 in. long will hold about 20 lb. of melted lead and can be brought to and kept in fusion with a large Bunsen burner. A bath of this size will permit a container about 3 in. by 2½ in. to be immersed, cold, without "freezing" the lead if brought well above the melting point.

In tests with substances whose heat-reactions are not definitely known, this form of retort saves breakages of condensers and tubing, for swelling of the assay and stoppage of the gooseneck simply forces exit through the seal. It goes without saying that the retort and all of its parts must be dry when placed in the hot bath, or there will be steam explosion and scattering of lead or hot material. Further, in bringing a solidly filled bath of lead to fusion, melt from the top, to avoid expansion under the solid lead and danger of cracking the container. Or the alternative may be used of running a small diameter wooden or metal rod to the bottom of the bath before setting it aside to solidify, so that a relief channel may be formed from top to bottom to take care of expansion when again fusing.

The retort can be taken apart while practically red hot and there is little temptation to use water on it for cooling. It is accessible for perfect cleaning and the cost is insignificant. As 1 in. of lead is equivalent to about 11 in. of water, a seal of an inch or two is enough for ordinary purposes, including collection of gas over mercury trough, potash bulbs and open scrubbers.

Crown Willamette Paper Co.,
Floriston, Cal.

Measuring Coke Oven Gas Used in Soaking Pits

INCREASING quantities of surplus gas from by-product coke oven plants are being consumed in various processes in steel mills and it is desirable to have an accurate and reliable measurement of this gas. For this purpose the Thomas meter has been applied, which measures the quantity of gas in standard units, such

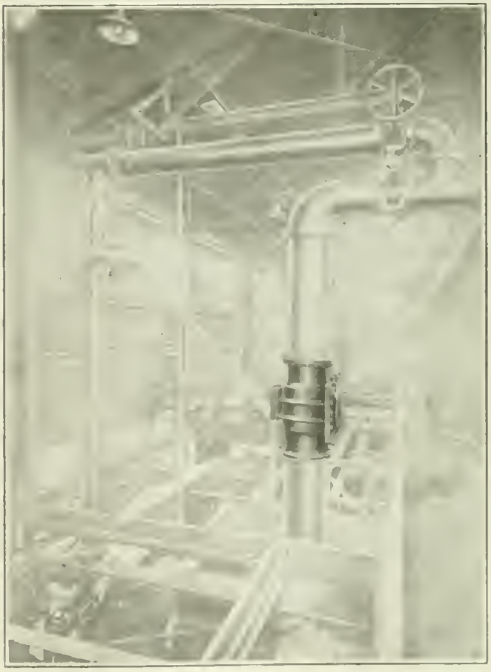


FIG 1. HOUSING INSTALLATION, BRIER HILL STEEL CO.

as cubic feet at 30-60, without any calculations or corrections for pressure and temperature, although these may vary through wide ranges. The total quantities (in cubic feet) are shown on an integrating meter and the rate of flow is shown graphically on a curve drawing instrument. The graphic chart obtained from this instrument is very useful to the superintendent of a coke oven plant, showing him at a glance the amount of gas being used for fuel in the coke ovens over any period, with variations in quantities clearly indicated.

The meter is installed in a housing which replaces a portion of the gas pipe line as shown in the accompanying illustration of an installation at the Brier Hill Steel Company, Youngstown, Ohio. The principle of the Thomas meter is that it measures the heat capacity of a gas electrically. The amount of electric heat necessary to raise a standard unit two degrees is used as a measure of the gas flowing through the meter. The electricity for heating the gas can be conducted on comparatively small wires, consequently the meters showing the amount of gas used can be placed in the superintendent's office or other desired location, which may be several hundred feet from the meter proper.

The graphic chart shows him at a glance just how much gas is being used at any time in the soaking pit building. The complete Thomas meter and recording panels are made and installed by the Cutler-Hammer Manufacturing Company of Milwaukee, Wis.

The Cost in Coal of Avoidable Belt Slip

TO show the extent of the loss of money through slipping of the main belt alone a chart, supplied us through the courtesy of the Cling-Surface Company, Buffalo, N. Y., is shown herewith, upon which this is easily ascertained. By glancing up and down column "D" of this chart it is evident that the "cost of avoidable belt slip per year in dollars" may vary all the way from the smallest sums into the thousands of dollars.

Where the power in the first place is generated by a steam engine and is then transmitted to a generator or to the main shaft through a main belt it is evident that the "entire coal pile" passes through that in the form of energy, literally speaking. If the belt slips, which it should not do, a certain portion of the coal pile does not

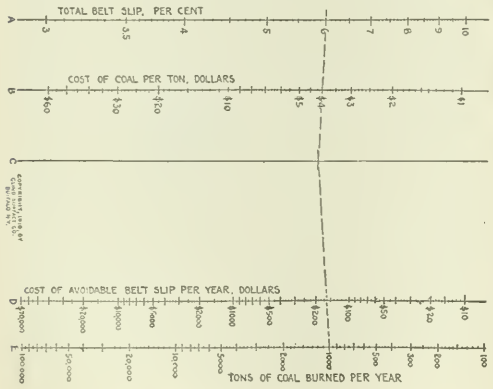

TOTAL BELT SLIP, PER CENT
COST OF COAL PER TON, DOLLARS
COST OF AVOIDABLE BELT SLIP PER YEAR, DOLLARS
TONS OF COAL BURNED PER YEAR

FIG. 1. CHART FOR DETERMINING COST OF BELT SLIP

"get through," but is lost into the atmosphere in the form of waste heat. A main belt is merely a "link" connecting the engine with the generator or with the machines themselves. In fact, every belt that transmits power is a connecting link and the efficiency of that link depends largely upon the freedom from slippage and the avoidance of strain on the shafts. Slipless, easy-running belts are most desirable.

To give a clear idea as to the meaning of "total belt slip per cent" take the following example: You find by means of a revolution counter that a given driven pulley is rotating only 940 times per minute. You figure that without slip it should rotate 1000 times per minute. Sixty revolutions per minute, therefore, are absolutely lost. Dividing this 60 by the r.p.m. that pulley should make you get 0.060, or 6 per cent, which is the "total belt slip." After having made this determination it is a simple matter to apply it to the chart and determine the money loss per year due to such slip.

Furthermore, belts which do not slip do not require tension and can be run easy or slack—every belt thus relieved of its tension reduces by that much the total plant friction load and this means also a longer-lived belt, cool bearings, less oil used, less time of men and machines lost during repairs and more power at the machines, for friction represents lost power.

A New End-Suction Centrifugal Pump

A new design of centrifugal pump manufactured by the Wheeler Condenser & Engineering Company, Carteret, N. J., is of special interest because of the unusual position of the suction opening. This opening, it will be noted, is directly beneath and parallel to the end bearing. In this position it is out of the way, yet it is in a convenient place for the erection men, for inspection, for upkeep, etc.

This arrangement makes it possible to place a pumping unit in a room of small ground area—considerably

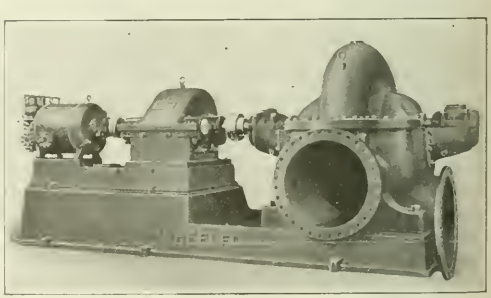


FIG. 1. ASSEMBLED VIEW OF END-SUCTION PUMP

smaller than where the suction end is opposite the outlet end, as is the most common practice. In many cases this also facilitates the making of pipe connections, saving elbows and reducing the length of piping.

The capacity of the particular pump shown is 45,000 gal. per min. against a head of 20 ft. The diameter of the outlet pipe is 36 inches. The speed of the pump is 240 r.p.m. and is coupled by a 10 to 1 reduction gear to a steam turbine, whose speed is 2400 r.p.m.

Personal

Messrs. G. W. AKERLOW and J. M. LUNDQUIST have opened an office as consulting and mechanical engineers in Denver. They will handle mill design, special machinery and oil shale refining plants.

Mr. WATSON BAIN, professor of applied chemistry at the University of Toronto, has been granted leave of absence for the duration of the war. He is going to Washington, D. C., where he will be on the staff of the Canadian mission.

Dr. JOHN E. BUCHER, professor of chemistry in Brown University, has been granted leave of absence for the second semester of the academic year, in order to devote himself to experimentation in chemical processes in the industry. He will continue to direct the work of certain advanced students in the university laboratory, but will be relieved of all teaching during the remainder of the year. Dr. Robert F. Chambers, a Brown graduate, will be acting head of the department during the second semester.

Mr. W. C. CAPRON has been advanced from the position of assistant chief engineer of the Washoe Reduction Works to that of mechanical superintendent of the same plant. A number of other changes in the engineering staff of the Anaconda Copper Mining Company have followed this change. Mr. C. D. WOODWARD has been transferred from assistant chief engineer of the Great Falls reduction department in Butte, where he will be chief electrician of all the Anaconda properties in Montana. Mr. Woodward is succeeded in Great Falls by Mr. GEORGE TYRON, formerly chief draftsman of the Washoe Plant. Mr. H. W. RUTHERFORD, designer, becomes superintendent of construction for Stack, Cottrell Treaters and Arsenic Plant, Washoe Reduction Works, succeeding Mr. W. E. MEALS, who becomes chief draftsman.

Dr. F. E. CARRUTH, formerly connected with the chemical division of the North Carolina Experiment Station, has become associated with the Schaefer Alkaloid Works, Maywood, N. J.

Mr. E. R. CRUTCHER, superintendent of the Judge Smelter, Park City, Utah, has resigned and will go to South America. He is succeeded by J. F. ELLSWORTH.

Mr. A. A. HAWKES has been named to succeed J. M. GOETCHIUS as vice president and director of the General Chemical Co. Mr. GOETCHIUS resigned in order to give his services to the Government.

Mr. HERBERT LONGSTAFF has been appointed St. Louis manager for the Asbestos Protected Metal Co., of Pittsburgh, Pa.

The following changes and additions have recently been made in the sales organization of the Pfadler Co., Rochester, N. Y.: Mr. W. E. FOSTER now represents them as manager of the Atlantic Coast Sales Division; vice, F. L. CRADDOCK, with headquarters at the New York office, 110 West Fortieth Street. Mr. PHILIP S. BARNES, formerly with the Avery Chemical Company, of Lowell, Mass., is now associated with the sales department as consulting chemical engineer, with headquarters at the New York office. On April 1st the Chicago office will be removed from the Schiller Building, where it has been for a number of years, to 1442 Conway Building. Mr. R. B. KILMER is in charge.

Dr. C. L. REESE, of E. I. du Pont de Nemours & Co., has been named chairman of the committee on dyestuffs and intermediates of the Chemical Alliance.

Mr. H. D. SAVAGE, manager of sales, has been elected vice president of the Locomotive Pulverized Fuel Company. He will also continue as vice president of the American Arch Company.

Mr. LEWIS SEARING, of the Denver Engineering Works Co., has sold his half interest in the Denver Engineering Works Co. to the Hardinge Conical Mill Co. Mr. Searing will terminate his connection with the company on June 1.

Dr. WILLIAM P. WOOD, assistant professor of chemical engineering at the University of Michigan, has resigned, to join the Signal Corps of the Army.

Current Market Reports

The Iron and Steel Market

There has been no revival of activity in the pig iron and finished steel markets since the reaffirmation of prices for another three months, to July 1, with slight revisions in pig iron and scrap prices. There was no particular reason to suppose that the market would increase in activity. There is heavy Government buying, heavier perhaps than early in the year, but this is not considered market activity, all such buying being practically in the form of allotments.

As to commercial steel buying, it is to be borne in mind that the steel mills are carrying on their books more than 12,000,000 tons of purely commercial business, entirely apart from war orders, direct from the Government, or indirect. These obligations represent something like normal requirements of regular buyers, chiefly jobbers and manufacturing consumers. These buyers have no occasion to enter into additional engagements, for distant deliveries, as conditions are not such as to enable them to gage their consumptive requirements far in advance. The incentives to forward buying that frequently exist are altogether absent now. There is no definite prospect of there being higher prices in future. There is no particular advantage in buying early to secure a place on order books as deliveries will be regulated by Government requirements and the Government's views as to the usefulness of the buyer's industrial operations. There may be lower prices fixed by the Government, in which case the buyer is protected, but the Government edict in this respect does not cover the buyer against declines in the open market, below the set prices, produced by open competition, and of such competitive selling there is a distinct possibility.

An additional cause for the dullness in the open market is the fact that new projects are lacking. The commercial requirements in steel, such as they are, come from regular buyers, who are already covered, and do not hinge upon new projects.

DELIVERIES MUCH HEAVIER

Transportation conditions have been steadily improving, and a double result follows. Shipments from mills are heavier, and material long delayed *en route* has been reaching the buyer, so that while shipments have increased, deliveries have increased still more. This is beginning to tell upon the situation, and the majority of buyers of finished steel products find themselves in much more comfortable position. It is quite possible that within a few weeks many buyers will request mills to reduce shipments.

Production of finished steel has not increased as much as shipments. At practically all mills in the past few weeks there has been a reduction of stocks accumulated in January and February, and in nearly all cases it is desired to reduce the stocks greatly, as much of the tonnage is sadly in the way, having accumulated by force of circumstances and not by design. Shipments of finished steel during the fore part of April may be estimated at about 90 per cent of capacity, and production at 80 to 85 per cent. Capacity having increased very materially of late, shipments are now at approximately the average rate that obtained in 1916, when the existing capacity was fully employed.

Pig iron production has increased very sharply in the past few weeks, from a rate of 25,000,000 tons a year or thereabouts in the early part of February to a present rate of close to 40,000,000 tons. The greatest production in a calendar year has been 39,400,000 tons, in 1916, while through the completion of 17 new furnaces since 1916 capacity at present is about 43,000,000 tons.

There remains some shortage of coke, but only in spots. Shipments of Connellsville coke have greatly increased and are now approximately equal to the requirements of the furnaces still tributary to the region. These requirements are materially less than formerly, by reason of the com-

pletion of so many by-product ovens, and further decreases are to occur as additional by-product ovens are completed. Since the beginning of 1917 by-product capacity has come in to the extent of about 4,500,000 tons a year, while new plants scheduled for completion within the next few months will add fully 6,500,000 tons more, making an addition of considerably more than 10,000,000 tons since the end of 1916, yet in 1916 there was coke sufficient for the production of 39,400,000 tons of pig iron, and the present blast furnace capacity, as just noted, is only about 43,000,000 tons. While Connellsville coke sold at $10 to $15 a ton before the Government set the price at $6, it is quite possible that coke will eventually seek a market at much below the Government limit.

Prices in Future

The only changes made in prices to rule from April 1 to June 30 were a reduction of $1 a ton in basic iron and reductions of $1 a ton in all descriptions of scrap upon which prices had been fixed. Basic iron dropped from $33 to $32, at furnace, and this brought Bessemer down from $36.30 to $35.20, as Bessemer is set at 10 per cent above basic.

It was made clear by the War Industries Board that the chief reason a general reduction in steel prices was not sought at the conference late in March was that the producers had had a hard time in the winter, with very irregular operations and consequently particularly high costs. The board's idea seemed to be to give the industry three months time without change in prices, and then consider conditions afresh. With the much steadier operations now possible costs are bound to decrease, although it is to be noted that wages were advanced about 10 per cent, effective October 1, just after the original price agreement was reached, and April 15 an additional advance of about 15 per cent becomes effective. Wages will then be very nearly double what they were in 1915, and almost triple what they were in 1898, as a result of five years of industrial depression.

On the one hand there is a distinct possibility of general, though not great, reductions in iron and steel prices July 1, by action of the Government, while on the other hand there are distinct possibilities of market declines through open competition, it being quite clear that all war requirements combined can hardly engage more than one-half the total productive capacity, while the strictly peace demand that remains can hardly be expected to absorb the other half. At the same time the general attitude of producers is that the set Government prices, prescribed as maximum, should in the general interest be regarded as minimum likewise.

For the long future, it is becoming clearer week by week that no return to former costs in the iron and steel industry is to be expected. Labor is on a different basis, and working conditions in the industry must be made such as to attract native born labor. Steel prices after the war may be, and probably will be, lower than at present, but no return to levels obtaining previous to the war can possibly be expected in view of conditions as they have lately been shaping themselves.

Non-Ferrous Metal Market

Monday, April 8—There has been practically no change in the tin situation and copper is moving steadily with demands being fairly well taken care of. The lead situation has eased up considerably and supplies are plentiful. Spelter continues weak.

Copper—Transportation facilities have improved and fewer delays have resulted. Consumers are being well supplied at present and although the demand from the Government and the Allies is expected to be increasingly heavy, the producers are expected to be able to meet them. The price remains at 23.50c. for producers and 24.67½c. for jobbers. Smelter production is estimated at 200,000,000 lb. per month.

Tin—Spot stocks are very low and few supplies are for sale. The market is very difficult and while it is not impossible to pick up small odd lots here and there, they are very scarce and are 99 per cent material. China is about the only source of supply at present and spot is held at around 90 cents with futures at 80 cents.

Lead—Lead is slightly lower and has sold in the New York market for from 7 to 7¼ cents. In E. St. Louis the price has been 6.90 to 7.17½ cents. The large producers are well sold up but supplies have been more freely offered by the small producers.

Spelter—Spelter continues to decline and has dropped to 6.90 to 7.00 cents E. St. Louis and 7¼ cents New York. The lower price will probably further decrease production.

Other Metals

Aluminium, lb., 98-99 per cent, virgin, Gov't price	.32
Bismuth, lb.	2.50-2.75
Cadmium, lb.	1.40
Nickel, electrolytic, lb.	.55
Silver, oz.	91⅝
Platinum, oz.	108.00
Palladium, oz.	150.00
Cobalt, lb.	3.25-3.50
Magnesium, lb.	2.00
Quicksilver, Cal.	120.00
Quicksilver, Mexican	115.00

Chemical Market

Coal Tar Products: The market was particularly quiet in most of the important items during the interval. Prices were somewhat easier in the crudes, due to the more liberal offerings and the falling off in the demand.

Benzol: The demand is confined mostly to spot material, but there is a fair volume of business passing on contract over short terms. It is said that some large contracts have been closed at a concession.

Toluol: Some large quantities have been released by the governmental authorities of late, for use in intermediates and dyes. The government appears to be determined not to permit offerings on the open market, although there are small quantities available from time to time.

Phenol: Offerings have been considerably augmented and with the demand quiet prices are slightly easier.

Naphthaline: While the demand is not pressing, offerings are light and prices are fairly well maintained.

Aniline Oil: The demand has been quite active of late and though there are resale lots available at a concession in price, producers are quite firm in their ideas.

Beta Naphthol: There has been an active demand for the technical material, but prices have held steady and unchanged, as there are large quantities available.

Benzoate of Soda: The consuming demand has not, as yet, been heavy, and, though there is some fluctuation in price, in general the position is unchanged.

Phthalic Anhydride: Some of the important factors are energetically endeavoring to secure business, and prices have depreciated under the strong competition in the market.

H. Acid: There are large quantities on the market, with the demand more or less routine and prices unchanged.

Resorcin: Considerable competition has developed and with only a moderate demand prevailing prices are easier.

Salicylic Acid: Is weak with the demand light because of inability to secure export licenses.

Sulphanilic Acid: Is not in heavy demand, but there are only a few producers and prices are unchanged.

Benzyl Chloride: There are only a few producers offering at present because of the scarcity of toluol, and prices are inclined higher.

Benzidine Base: Is only fairly active and prices are unchanged with a moderate production.

Heavy Chemicals: The feature of the market during the past two weeks has been the recovery of caustic soda from the low point recorded in our last issue. Material shipped to this point had accumulated to such an extent that pressure was brought on owners with view to releasing cars and as a consequence caustic was offered at concessions. Aside from this movement the market has been quiet and the trade has as a rule been disappointed with the amount of trading that has come to hand.

Caustic Soda: From a price of below 4c., the market has

advanced to the 5c., level with trading noted at this figure spot and contracts closed basis works freight as high as 5½c. Several important consumers have entered the market of late and in addition to this several of the producers have been buyers with the result that the market has presented more activity than at any period since last October when the famous slump occurred. The spot market has been fairly well cleaned up and offers have been rather restricted of late with the producers well in control of the situation once more. An interesting feature of the market during the fortnight was the announcement of several producers who are now quoting 3½c. basis 60% works for 1919 business. This price is considered high by consumers but producers claim the increased cost of labor, coal, lime and other incidentals warrants such a level. Business is reported to have passed at the level mentioned.

Soda Ash: This market did not respond to the upward trend in caustic until the past few days when an active inquiry developed for barrels and after a low period of selling the market advanced again to 3.10 and 3.15 f.a.s. The inquiry of late has been principally for export barrels. Bags have been neglected with trading at from 2.50 to 2.60. Dense ash has been tight at 3.75 double bags New York.

Copper Sulphate: Resales have depressed what should in the ordinary course of events be a rising market. Nichols 98/99% large crystals have sold as low as 8.50 although business has passed at 9c. and perhaps a trifle higher from certain quarters.

Cyanide of Soda: Some buying has been reported and the market was at one time up to 40c., but at the moment of writing 38c. can be done for domestic material.

Acetic Acid: This has been one of the features of the chemical market. Sales have occurred at such a wide variance that prices mean nothing. Locating supplies seems to be the main accomplishment and a consumer will pay most any price the seller demands. Prices really mean nothing as they change from hour to hour.

Sulphuric Acid: An easier feeling has prevailed owing to the fact that quite a few cars of 66 brimstone acid have appeared on the market ranging in price from $35.00 upward. Even at these prices buyers have not appeared interested. Sixty degree material has been offered at $25.00 sellers tanks works. Sixty-six brimstone acid is held at $40.00 drums works.

Oleum: This market has followed sulphuric and resales have been made at $70.00 drums and $65.00 tanks works.

Nitric Acid: As a result of the strong nitrate of soda situation the market is firmer and resale material at 8¾c. has been eliminated and little under 9c. can now be obtained.

Nitrate of Soda: Definite word from the government fixing the price at which nitrate of soda may be sold is expected. In the meanwhile the government frowns in resales but these have been occurring at prices ranging from 5.20 upward at various points. The market looks rather uncertain with a probability of higher prices.

Aqua Ammonia: Despite the government's desires there has been considerable trading but the trade is rather inclined to go slow and prices are somewhat lower than when last reported. Business has passed in 26 degree material at 25c. to 27c.

Sodium Nitrite: No particular activity is noted and resales have occurred at 33c. to 35c. A new producer offers contracts at 30c. f.o.b. works.

Bichromate of Soda: The market has been manipulated to a prouounced extent and short interests have been covering whenever possible without risking too much of an advancing market. Sales have occurred between 22c. and 25c., spot and works, and there is no telling what may happen from day to day.

Citric Acid: This has been probably the most fluctuating item in the chemical trade during the interval. An advance of 22 points was scored in one day. The product sold as high as $1.00 but at the moment of writing domestic material is available at 88c.

Acetic Anhydride: Consumers working on government requirements may secure material at $1.15 but outside consumers are compelled to pay from $1.50 to $1.60 for spot supplies.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, APRIL 8, 1918

Acetic anhydride	lb.	1.35 —	1 50
Acetone, drums	lb.	Nominal	
Acid, acetic, 28 per cent	lb.	.09 —	.11
Acetic, 56 per cent	lb.	.19 —	.20
Acetic, glacial, 99½ per cent., carboys	lb.	.37 —	.38
Boric, crystals	lb.	.13½ —	.14½
Citric, crystals	lb.	.88 —	90
Hydrochloric, C. P.	lb.	.08 —	.08½
Hydrochloric, 20 deg	lb.	.02½ —	.02½
Hydrochloric, conc., 22 deg	lb.	.02½ —	.03
Hydrofluoric, 30 per cent., in barrels	lb.	.06 —	.06½
Lactic, 44 per cent	lb.	.13 —	15
Lactic, 22 per cent	lb.	.05½ —	.06½
Nitric, 36 deg	lb.	.08½ —	.08¾
Nitric, 42 deg	lb.	.09 —	.09½
Oxalic, crystals	lb.	44 —	45
Phosphoric, 47-50 per cent. paste	lb.	08 —	.10
Phosphoric, ref. 50 per cent	lb.	26 —	
Picric	lb.	Nominal	
Pyrogallic, resublimed	lb.	3 10 —	3 15
Sulphuric, 60 deg	ton	25.00 —	27.50
Sulphuric, 66 deg	ton	40 00 —	45.00
Sulphuric, oleum (Fuming), tank cars	ton	60.00 —	75.00
Tannic, U. S. P., bulk	lb.	1.30 —	1.35
Tartaric, crystals	lb.	75 —	.78
Tungstic, per lb. of W	lb.	1 80 —	1.90
Alcohol, sugar cane, 188 proof	gal.	4.93 —	4.95
Alcohol, wood, 95 per cent	gal.	.90½ —	.91
Alcohol, denatured, 180 proof	gal.	.68 —	.69
Alum, ammonia lump	lb.	.04 —	.04½
Alum, chrome ammonium	lb.	.18 —	.19
Alum, chrome potassium	lb.	.19 —	.20
Alum, chrome sodium	lb.	.12½ —	.13
Alum, potash lump	lb.	.09 —	.09½
Aluminum sulphate, technical	lb.	.02 —	.02½
Aluminum sulphate, iron free	lb.	.03½ —	.03½
Ammonia aqua, 26 deg. carboys	lb.	.25 —	.26
Ammonia, anhydrous	lb.	Nominal	
Ammonium carbonate	lb.	.11 —	12
Ammonium nitrate	lb.	(Fixed price)	.14
Ammonium, sulphate domestic	lb.	.07½ —	.08
Amyl acetate	gal.	5 00 —	5.25
Arsenic, white	lb.	.16½ —	.17½
Arsenic, red	lb.	.65 —	70
Barium carbonate, 99 per cent	ton	80 00 —	90 00
Barium carbonate, 97-98 per cent	ton	65 00 —	67 00
Barium chloride	ton	65.00 —	85 00
Barium sulphate (Blanc Fixe, powder)	lb.	.03½ —	.04
Barium nitrate	lb.	.09½ —	10
Barium peroxide, basis 70 per cent	lb.	.30 —	32
Bleaching powder, 35 per cent chlorine	lb.	.02½ —	.02½
Borax, crystals, sacks	lb.	.07½ —	.08½
Brimstone, crude	ton	Nominal	
Bromine, technical	lb.	75 —	
Calcium, acetate, crude	lb.	Nominal	
Calcium, carbide	lb.	13 —	14
Calcium chloride, 70-75 per cent., fused, lump	ton	27 50 —	30 00
Calcium peroxide	lb.	1.60 —	1.70
Calcium phosphate	lb.	.34 —	35
Calcium sulphate 98-99 per cent	lb.	.09 —	.09½
Carbon bisulphide	lb.	.08 —	10
Carbon tetrachloride, drums	lb	.15½ —	.16
Carbonyl chloride (phosgene)	lb	1 10 —	1 50
Caustic potash, 88-92 per cent	lb.	84 —	85
Caustic soda, 76 per cent	lb	.05 —	.05½
Chlorine, liquid	lb.	15 —	.18
Cobalt oxide	lb.	1 60 —	1.65
Copperas	lb.	.01½ —	.01½
Copper carbonate	lb.	30 —	40
Copper cyanide	lb.	.75 —	.78
Copper sulphate, 99 per cent., large crystals	lb.	.08¼ —	.09½
Cream of tartar, crystals	lb.	.58 —	60
Epsom salt, bags, U.S.P.	lb.	.03½ —	.03¾
Formaldehyde, 40 per cent	lb.	.19½ —	20
Glauber's salt	100 lb.	1.50 —	2 00
Glycerine, bulk, C. P.	lb.	.68½ —	69
Iodine, resublimed	lb.	4 25 —	4 35
Iron oxide	lb.	13 —	.15
Lead, acetate, white crystals	lb.	.17 —	.18
Lead arsenate (Paste)	lb.	.15 —	.18
Lead nitrate	lb.	15 —	16
Litharge, American	lb.	.09½ —	.11½
Lithium carbonate	lb.	1 50 —	2 00
Manganese dioxide, U. S. P.	lb.	70 —	75
Magnesium carbonate, technical	lb.	.10½ —	11
Nickel salt, single	lb.	14 —	15
Nickel salt, double	lb.	12 —	14
Phosgene, see Carbonyl chloride			
Phosphorus, red	lb.	1 30 —	1 50
Phosphorus, yellow	lb.	1 50 —	1 60
Potassium bichromate	lb	44 —	46
Potassium bromide granular	lb.	1 35 —	1 50
Potassium carbonate calcined, 85-90 per cent	lb.	95 —	1 05
Potassium chlorate, crystals	lb.	36 —	40
Potassium cyanide, 98-99 per cent	lb.	Nominal	
Potassium iodide	lb.	3 75 —	3 80
Potassium muriate 80-85 p. c. basis of 80 p. c	ton	340 00 —	350 00
Potassium nitrate	lb.	.27 —	.31
Potassium permanganate (U. S. P.)	lb.	4.00 —	4.10
Potassium prussiate, red	lb	2 80 —	2 90
Potassium prussiate, yellow	lb	1 20 —	1 25
Potassium sulphate, 90-95 p. c basis 90 p. c	ton	Nominal	
Rochelle salts	lb.	40 —	42
Salammoniac, gray gran	lb	16 —	17
Salammoniac, white grao	lb.	15½ —	16
Sal soda	100 lb	1 35 —	1 40
Salt cake	ton	24 00 —	27 00
Silver cyanide, based on market price of silver	oz		
Silver nitrate	oz	59½ —	.60½

Soda ash, 58 per cent., light, flat	100 lb.	2.60	—	2.70
Soda ash, 58 per cent., dense, flat	100 lb.	3.75	—	.....
Sodium acetate	lb.	.23	—	.24
Sodium bicarbonate, domestic	lb.	.02½	—	.03
Sodium bicarbonate, English	lb.	.....	—	.....
Sodium bichromate	lb.	.22½	—	.23
Sodium bisulphite, powd	lb.	.05½	—	.06
Sodium chlorate	lb.	.24	—	.25
Sodium cyanide	lb.	.38	—	.40
Sodium fluoride, commercial	lb.	.17	—	.18
Sodium hyposulphite	lb.	.02½	—	.....
Sodium molybdate, per lb. of Mo	lb.	2.50	—	.....
Sodium nitrate, 95%	100 lb.	Nominal		
Sodium nitrate	lb.	.33	—	.34
Sodium nitrite	lb.	.50	—	.52
Sodium peroxide	lb.	.04	—	.05
Sodium phosphate	lb.	.39	—	.40
Sodium prussiate, yellow	lb.	.04½	—	.05
Sodium silicate, liquid (60 deg.)	lb.	.02½	—	.03
Sodium sulphide, 30 per cent., crystals	lb.	.05	—	.05½
Sodium sulphide, 60 per cent., fused	lb.	Nominal		
Sodium sulphite	lb.	.25	—	.35
Strontium nitrate	lb.	.06	—	.06½
Sulphur chloride, drums	lb.	.15	—	.40
Sulphur dioxide, liquid, in cylinders	100 lb.	4.05	—	4.60
Sulphur, flowers, sublimed	100 lb.	3.70	—	3.85
Sulphur, roll	ton	Nominal		
Sulphur, crude	lb.	.23½	—	.24½
Tin bichloride, 50 deg.	lb.	.78	—	.80
Tin oxide	lb.	.25	—	.30
Zinc carbonate	lb.	.12½	—	.13
Zinc chloride	lb.	Nominal		
Zinc cyanide	lb.	.14	—	.16
Zinc dust, 350 mesh	lb.	.14	—	.15
Zinc oxide, American process XX	lb.	.06	—	.07
Zinc sulphate	lb.	.....	—	.....

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.30	—	35
Benzol, 90 per cent.	gal.	.....	—	.....
Toluol, pure water white	gal.	Nominal		
Xylol, pure, water white	gal.	.35	—	50
Solvent naphtha, water white	gal.	.17	—	.22
Solvent naphtha, crude, heavy	gal.	.13	—	.16
Creosote oil, 25 per cent.	gal.	.33	—	.35
Dip oil, 20 per cent.	gal.	.29	—	.30
Pitch, various grades	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent.	lb.	1.05	—	1.10
Carbolic acid, crude, 50 per cent.	lb.	.60	—	.65
Carbolic acid, crude, 25 per cent	lb.	.35	—	.38
Cresol, U. S. P.	lb.	.18	—	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00	—	1.25
Alpha naphthol, distilled	lb.	1.60	—	2.00
Alpha naphthylamine	lb.	.58	—	60
Aniline oil, drums extra	lb.	.25½	—	.27
Aniline salts	lb.	.32	—	.34
Anthracene, 80 per cent.	lb.	.50	—	.65
Benzaldehyde (f.f.c.)	lb.	5.00	—	5.50
Benzidine, base	lb.	1.75	—	1.85
Benzidine, sulphate	lb.	1.40	—	1.50
Benzoic acid U. S. P.	lb.	4.25	—	4.50
Benzoate of Soda, U. S. P.	lb.	4.00	—	4.25
Benzyl chloride	lb.	2.25	—	2.50
Beta naphthol benzoate	lb.	10.00	—	12.00
Beta naphthol, sublimed	lb.	.85	—	.90
Beta naphthylamine, sublimed	lb.	2.65	—	.....
Dichlor benzol	lb.	.12	—	.18
Diethylaniline	lb.	4.00	—	5.00
Dinitro benzol	lb.	.35	—	.40
Dinitrochlorbenzol	lb.	.40	—	.42
Dinitronaphthaline	lb.	.55	—	.60
Dinitrotoluol	lb.	.55	—	.60
Dinitrophenol	lb.	.46	—	.50
Dimethylaniline	lb.	.65	—	.70
Diphenylamine	lb.	1.00	—	1.10
H-acid	lb.	2.25	—	2.50
Metaphenylenediamine	lb.	2.00	—	2.25
Monochlorbenzol	lb.	.19	—	.22
Naphthalene, flake	lb.	.10½	—	.10½
Naphthalene, balls	lb.	.12	—	.14
Naphthionic acid, crude	lb.	1.20	—	1.30
Naphthylamin-di-sulphonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.45	—	.50
Nitro toluol	lb.	.50	—	.55
Ortho-amidophenol	lb.	.....	—	.....
Ortho-dichlor-benzol	lb.	.15	—	.18
Ortho-toluidine	lb.	1.25	—	1.30
Ortho-nitro-toluol	lb.	.75	—	1.00
Para-amidophenol, base	lb.	3.50	—	3.75
Para-amido-phenol, H. Cl.	lb.	4.00	—	5.00
Para-dichlor-benzol	lb.	.12	—	.15
Paranitraniline	lb.	1.25	—	1.30
Para-nitro-toluol	lb.	1.50	—	1.60
Paraphenylenediamine (base)	lb.	3.00	—	3.25
Para toluidine	lb.	2.25	—	2.50
Phthalic acid anhydride	lb.	3.50	—	4.00
Phenol, U. S. P.	lb.	.53	—	.54
Resorcin, technical	lb.	5.75	—	6.00
Resorcin, pure	lb.	8.50	—	9.00
Salicylic acid	lb.	1.00	—	1.10
Salol	lb.	1.85	—	2.00
Sulphanilic acid, crude	lb.	.32	—	.35
Tolidin	lb.	2.50	—	.....
Toluidine-mixture	lb.	.75	—	.85

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4.00	—	.....
Corning, Ohio	bbl.	2.85	—	.....
Somerset, Ky	bbl.	2.60	—	.....
Wooster, Ohio	bbl.	2.58	—	.....
Indiana	bbl.	2.18	—	.....
Illinois	bbl.	2.32	—	.....
Oklahoma and Kansas	bbl.	2.25	—	.....
Caddo, La., light	bbl.	2.25	—	.....
Corsicana, Tex., light	bbl.	2.35	—	.....
California	bbl.	.98	—	1.32
Gulf Coast	bbl.	1.35	—	.....

Fuel Oil

New York	gal.	.11	—	.....
Pittsburgh	gal.	.07½	—	.10
Oklahoma-Kans	bbl.	1.05	—	2.75
Texas	bbl.	1.50	—	1.90
Los Angeles	bbl.	1.52	—	.....
San Francisco	bbl.	1.45	—	.....

Gasoline (Wholesale)

New York	gal.	.24	—	.....
Boston	gal.	.25	—	.....
Pittsburgh	gal.	.27	—	.....
Chicago	gal.	.21	—	.....
Oklahoma	gal.	.25	—	.....
San Francisco	gal.	.20	—	.....

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.21	—	.22
Cylinder, light	gal.	.36	—	.38
Cylinder, dark	gal.	.35	—	.36
Paraffine, high viscosity	gal.	.40	—	.41
Paraffine, .903 sp. gr.	gal.	.36	—	.38
Paraffine, .865 sp. gr.	gal.	.26	—	.28

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f.o.b. Florida	gal.	.44	—	.....
Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.53	—	.....
Pine oil, destructively distilled	gal.	.49	—	.53
Pine-tar oil, sp. gr., 1.025-1.035	gal.	.35	—	.....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.40	—	.....
Pine oil, light, sp. gr. 0.950, tank cars, f. o. b. works	gal.	.37	—	.....
Pine oil, heavy, sp. gr. 1.025, tank cars, f. o. b. works	gal.	.26	—	.....
Pine tar, thin, sp. gr. 1.060-1.080	gal.	.30	—	.....
Turpentine, crude, sp. gr. 0.980-1.000	gal.	.40	—	.....
Hardwood oil, f. o. b. Michigan, sp. gr. 0.960-0.990	gal.	.19	—	.....
Hardwood oil, f. o. b. Michigan, sp. gr. 1.06-1.08	gal.	.19	—	.....
Wood creosote, ref. f. o. b. Florida	gal.	.31	—	.....

Vegetable and Other Oils

China wood oil	lb.	.23	—	.24
Cottonseed oil, crude	lb.	.17½	—	.18
Linseed oil, raw, cars	gal.	1.55	—	1.57
Peanut oil, crude	gal.	1.37	—	.....
Rosin oil, first run	gal.	.41	—	.....
Rosin oil, fourth run	gal.	.58	—	.....
Soya bean oil, Manchuria	lb.	.19	—	.19½
Turpentine, spirits	gal.	.41	—	.....

Miscellaneous Materials

Barytes, floated, white, foreign	ton	Nominal		
Barytes, floated, white, domestic	ton	30.00	—	36.00
Beeswax, white, pure	lb.	.56	—	.64
Casein	lb.	.22	—	.30
Chalk, light, precipitated, English	lb.	.....	—	.....
China clay, imported, lump	ton	17.50	—	36.00
China clay, domestic, lump	ton	12.50	—	20.00
Feldspar	ton	8.00	—	12.00
Fuller's earth, powdered	100 lb.	1.00	—	1.50
Graphite, flake	lb.	.15	—	.18
Ozokerite, crude, brown	lb.	.65	—	.75
Ozokerite, American, refined, white	lb.	.75	—	1.00
Red lead, dry, carloads	lb.	.10	—	.11½
Rosin, 280 lb.	bbl.	6.15	—	.....
Soapstone	ton	10.00	—	12.50
Talc, American, white	ton	15.00	—	22.00
White lead, dry	lb.	.09	—	.10

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	Nominal		
Chrome cement, Grecian	net ton	Nominal		
Clay brick, 1st quality fireclay	per 1000	50.00	—	55.00
Clay brick, second quality	per 1000	35.00	—	40.00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined	ton	85.00	—	90.00
Magnesite, Grecian, dead burned	net ton	135.00	—	140.00
Magnesia brick, Grecian, 9x4½x2½	per 1000	50.00	—	60.00
Silica brick				

Ferroalloys

Ferrocarbontitanium, 15-18 per cent., carloads, f.o.b. Niagara Falls, N. Y.	ton	200.00	—	.....
Ferrocerium	lb.	18.00	—	.....
Ferrochromium, per lb. of Cr	lb.	.50	—	.....
Ferromanganese, domestic, 80 per cent	ton	250.00	—	275.00
Ferromanganese, English	ton	325.00	—	.....
Ferromolybdenum, per lb. of Mo	lb.	5.00	—	.....
Ferrosilicon, 75 per cent., f.o.b. N. Y.	ton	.....	—	.....
Ferrosilicon, 50 per cent., carloads, del., Pittsburgh	ton	180.00	—	190.00
Ferrosilicon, 50 per cent., contract	ton	100.00	—	175.00
Ferrosilicon, 50 per cent., f.o.b. Pittsburgh	lb.	2.25	—	2.35
Ferrotuugsten, 75-85 per cent., f.o.b. Pittsburgh	lb.	7.00	—	7.50
Ferrouranium, f.o.b. works, per lb. of U	lb.	4.00	—	5.00
Ferrovanadium, f.o.b. works				

Ores and Semi-finished Products

Antimony ore, per unit		1.60	—	1.75
Chrome ore, 48 per cent. minimum, f.o.b. Cal., per unit	ton	1.50	—	1.75
Chrome ore, 43 per cent. and over, New York, per unit	ton	1.50	—	.....
Manganese ore, 48 per cent. and over, per unit	ton	1.20	—	.....
Manganese ore, chemical	ton	80.00	—	100.00
Molybdenite, per lb. of MoS_2	lb.	1.80	—	.....
Tuugsten, Scheelite, per unit of WO_3	ton	20.00	—	24.50
Tuugsten, Wolframite, per unit of WO_3	ton	20.00	—	24.00
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	.....
Pyrites, foreign	unit	.17	—	.17½
Pyrites, domestic	unit	.28	—	.30

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

ALABAMA

BIRMINGHAM.—The National Steel Products Company is making rapid progress in the erection of a large new local plant to be devoted to the manufacture of steel castings. At the recent meeting of the board of directors, E. M. Kilby, who is vice-president of the Kilby Frog & Switch Company, was elected president of the National company.

ARIZONA

CHLORIDE.—The Hackberry Consolidated Mining Company is considering plans for the construction of a new mill for the treatment of its lead-zinc ore. The company is engaging in extensive development work at its properties.

COLORADO SPRINGS.—Poston & Blumfield have recently acquired extensive copper properties in the Squaw Peak district, near Clarksdale, and are planning for early development.

PRESCOTT.—The Copper Valley Mining Company, recently incorporated, and which acquired the Ehle claims in Skull Valley, has commenced development work, and it is said the company is contemplating the erection of a mill.

TOMBSTONE.—The Broskaw Mining Company is making rapid progress in the installation of compressors and other mining machinery at its properties. The company is considering plans for the construction of a new mill for the treatment of vanadium ore.

TUCSON.—The Pima Smelter & Refining Company, recently incorporated with a capital of $1 000,000, is planning for the removal of its furnace plant now in operation at Socorro, New Mexico, to a site now under consideration near the city. The company has already placed orders for its converter equipment.

MAMMOTH.—The E. W. Childs molybdenite properties on Copper Creek, near Mammoth, have been taken over by new interests for a consideration said to be about $200,000, and extensive development work is planned. In the past, the milling of the ore has been considered rather difficult, due to its copper contents, but it is planned to employ a new process whereby the copper will be eliminated by means of hydrochloric acid, and thereafter saved by electrostatic deposition, the molybdenum being left available for concentration by flotation.

ARKANSAS

HARRISON.—Ika Kilgore is having plans prepared for the construction of a new 100-ton concentrating mill for the handling of ores from nearby lead and zinc mines.

HOPE.—Operations have been inaugurated in the new plant of the Hope Fertilizer Company recently completed. It is planned to operate both the new and the old plants to supply the large demand for this product.

ROGERS.—M. F. Gurler, of Tulsa Okla., and H. C. Holderman, Joplin, Mo., have leased approximately 2,000 acres of local property and are planning to develop the copper deposits.

RUSH E. L. Standley, operating a local plant for the manufacture of ore concentrating equipment, is planning for the establishment of a branch works at Yellville.

CALIFORNIA

FRESNO.—The San Joaquin Light & Power Corporation has made application to the State Water Supply Commission for permission to appropriate a water flow on the Kern River for a new hydroelectric power plant. The proposed station will have a capacity of about 20,000 horsepower, and is estimated to cost $1,000,000.

MARICOPA.—The Trojan Oil Company is making rapid progress in the construction of a large new refining and absorption plant for the extraction of gasoline from gas in the Aaktop field, near Calgary.

MARTINEZ.—The Butters Chemical Company is rushing to completion its new local electrolytic zinc plant, and it is expected that operations will soon be inaugurated.

MARTINEZ.—It is reported that huge additions will be made to the local plant of the Hercules Powder Company, including several additional nitric and sulphuric acid units, and seven more units for the manufacture of T.N.T. The company holds large contracts from both the Army and Navy Departments and it is understood that the new works will give employment to about 4000 hands.

OROVILLE.—The Western Ore Company is planning for the construction of a new concentration plant at its chrome claims at Lime Saddle, near Oroville.

SANTA ROSA.—The American Products Company has recently been organized to operate in Sonoma County, and will engage in the manufacture of printing inks and dyes.

COLORADO

DENVER.—The Queen City Foundry Company is planning for the immediate installation of a new one-ton Booth-Hall electric steel furnace, to replace the converter equipment now in use. The furnace which is rated at 300 kva., has a holding capacity of three-quarters to one ton. The Denver Gas & Electric Company will supply energy for the operation of the furnace.

GEORGETOWN.—The W. J. Chamberlain Ore Company has announced that it will close and dismantle its sampling works at Georgetown, Breckenridge and Blackhawk. It is said that the shutdown is due to the high cost of operation.

DELAWARE

DELAWARE CITY.—The United States Government, Ordnance Department, is said to be negotiating for the purchase of a large tract of land at Port Penn, near Delaware City, for the construction of a large new shell-loading plant. The plant will give employment to about 5000 hands.

WILMINGTON.—The E. I. duPont De-Nemours Company is planning for the manufacture of pipes and auxiliary equipment used in munitions works, in the plant of the B. F. Shaw Company, Second and Lombard Streets, recently acquired.

CONNECTICUT

FORESTVILLE.—A portion of the plant of the Bryce Manufacturing Company, Fredericks Street, manufacturer of ball bearings, etc., was recently destroyed by fire. The loss is estimated at about $50,-000.

WATERBURY.—The American Brass Company has recently awarded a contract for the construction of a new one-story brick, steel and concrete addition to its plant, about 50 x 105 feet. The Sperry Engineering Company, New Haven, is the contractor.

GEORGIA

MACON.—Contract has been awarded by the Macon Gas Company for the construction of a new addition to its gas works to provide an increased capacity of approximately 10,000,000 cubic feet per month. The addition is estimated to cost $40,000, and is expected to be entirely completed by September 1. The Parker Russell Mining & Manufacturing Company, St. Louis, Mo., is the contractor.

IDAHO

KELTON.—The Mercher Mining Company is planning to inaugurate operations in its new 100-ton concentrating plant before the close of the month. This will also include flotation.

MURRAY.—The Miners Smelting & Refining Company has recently completed its organization plans and is contemplating the construction of a new plant on Coeur d'Alene Lake. C T Kennan, Murray is interested in the company.

BOISE.—The Northwestern Development Company has commenced the operation of the Ranger copper claims, about twelve miles east of Salmon, Lemhi County. The company is considering plans for the construction of a large new concentrating plant.

ILLINOIS

CHICAGO.—J. L. Sparks, West Grand Avenue, is making rapid progress in the construction of a new one-story foundry, about 50 x 75 feet, at 1723 Carroll Avenue. The structure is estimated to cost $10,000.

CHICAGO.—The plant of the Phoenix Hermetic Company, manufacturer of glass jars, etc., was recently partially destroyed by fire, with loss estimated at $18,000.

CHICAGO.—A new one-story foundry, about 175 x 225 feet, is being erected at Hegewisch, Ill. by the Western Steel Car & Foundry Company, One Hundred and Thirty-sixth Street. The structure will cost $50,000.

CHICAGO.—The Illinois Steel Company has completed the erection of extensive additions to its Gary plant, including four additional furnaces, ore docks, rolling mills, and a Bessemer duplex plant. These mills are now the largest single unit of iron and steel producers in the world, and the plant has been increased by about fifty per cent since the war. The entire work is estimated to have cost approximately $20,000,-000.

DECATUR.—The Leader Iron Works is making rapid progress in the construction of a new one-story addition to its plant, about 50 x 200 feet, to cost $10,000.

INDIANA

INDIANA HARBOR.—The Mark Manufacturing Company is planning to inaugurate operations in its new 80-inch plate mill at its North Harbor steel works at an early date. Construction work on other additions to the plant is progressing rapidly; the billet and blooming mills are expected to be completed within the next month, and the company will soon place in operation four open hearth blast furnaces. It is also expected to complete the construction of the coke ovens before the end of the year. About 4,000 hands will be employed for initial operations.

EAST CHICAGO.—The Green Engineering Company, South Kennedy Avenue, has had plans prepared for the construction of a new one-story foundry. The structure will be about 45 x 100 feet, and is estimated to cost $50,000.

IOWA

OTTUMWA.—The plant of the Morey Clay Products Company was partially destroyed by fire on March 19, with loss estimated at $25,000.

KENTUCKY

WINCHESTER.—The Ken-See Mineral Company, recently incorporated with a capital of $25,000, is planning for the development of fluorspar lands near Marion. The company will commence the installation of the necessary equipment at an early date. Fielding H. Yost is president.

LOUISIANA

LAKE CHARLES.—The Lambert Chemical Company, St. Louis, Mo., has broken ground for the construction of the first unit of a large new manufacturing plant. The company recently acquired a local tract having a frontage of 800 feet as a site for the location of the works.

NEW ORLEANS.—The E. Z. Opener Bag Company has acquired property fronting on Toulouse, Scott and Cortez Streets, about 120 x 329 feet, comprising five-story and four-story factory buildings and warehouse, and is planning for extensive improvements and the installation of new equipment to cost about $50,000, for the manufacture of paper bags. H E Westervelt is president

NEW ORLEANS.—The United States Sulphur Company, Inc., has filed notice of a change in its corporate name to the American Brimstone Company, Inc.

SHREVEPORT.—The Equitable Window Glass Company, Buckhannon, W Va., has taken over the plant of the National Window Glass Company, Cedar Grove, near Shreveport, for the establishment of a new manufacturing plant.

SHREVEPORT.—The Marine Oil & Refining Company is rushing to completion the erection of a new refinery at Cedar Grove, near Shreveport, and it is expected that operations will be inaugurated at an early date.

MASSACHUSETTS

CONCORD JUNCTION.—The plant of the Whitman & Pratt Rendering Company was recently totally destroyed by fire on March 21, with loss estimated at $150,000. A large quantity of fertilizer and many hundreds of cases of soap were also destroyed.

WORCESTER.—The Crompton & Knowles Loom Works, 93 Grand Street, have commenced the construction of a new one-story addition, about 55 x 185, at their plant. The structure is estimated to cost $20,000. E. D. Ward, 82 Foster Street, Worcester, is the contractor.

GREENDALE.—Fire, caused by an explosion, damaged the plant of the Shepard Manufacturing Company, manufacturer of ferrotype plates, to the extent of about $10,000, on March 28. The company had been engaged on some important work for the Government.

MICHIGAN

ALMA.—Operations have been inaugurated in the new local plant of the Ex-Cell-All Paint Company, and it is said that plans are under consideration for additions. The company was formerly located in Big Rapids and Marion.

DETROIT.—A new one-story plant, about 25 x 100 feet, will be erected by the General Aluminum & Brass Manufacturing Company, St. Aubin Street. The structure is estimated to cost $30,000. Contract has been awarded to the Austin Company, Cleveland, Ohio.

HOUGHTON.—The new 10,000 kw. power plant of Calumet & Hecla is rapidly nearing completion at its works on Lake Linden.

TWIN BRIDGES.—The Crystal Lake Mining Company is making rapid progress in the construction of a new concentrating mill at its properties.

MINNESOTA

BRAINERD.—The Brainerd Gas & Electric Company is planning for the construction of a new addition to its gas generating plant to cost about $10,000. It is planned to have the structure ready for operation by June 30.

ST. PAUL.—Plans are under consideration by the Gas Traction Foundry Company for the construction of a new one-story foundry, about 100 x 300 feet. The structure is estimated to cost about $65,000.

MISSOURI

ST. JOSEPH.—The plant of the Berry Foundry Company, Fifth and Oak Streets, was partially destroyed by fire recently, with loss estimated at $75,000. The company was engaged upon Government contracts. G. D. Berry is president.

ST. LOUIS.—The Tri-City Steel Company is planning for the construction of a new one-story steel rolling mills, about 100 x 200 feet, at Madison, Ill.

ST. LOUIS.—The Certain-teed Products Corporation has acquired a tract of land comprising about six acres on Union Avenue, between Brown Avenue and the Terminal tracks, as a site for the construction of a new plant for the manufacture of paints. The plant will be a four-story concrete building, and will have a capacity of about 4,000,000 gallons per year. Plans are now in course of preparation by Klipstein & Rathman, St. Louis.

ST. LOUIS.—The St. Louis Coke & Chemical Company is planning for the erection of a large new plant, including a by-product coke oven and two blast furnaces, on a site comprising about 300 acres recently acquired, near Granite City, Ill. The property was purchased for a consideration said to be in the neighborhood of $200,000. The new works will engage in the manufacture of toluol, ammonia, naphtha, benzol, metallurgical and domestic coke, gas, etc., and the project is estimated to involve an expenditure of approximately $5,000,000. L. E. Fisher is vice-president and general manager.

KANSAS CITY.—The Patent Vulcanite Roofing Company has had plans prepared for the construction of a new one-story addition to its plant on Twelfth Street, about 90 x 150 feet.

MONTANA

SALTESE.—The Tarbox Mining Company is planning for the early construction of a new 300-ton concentration mill. Richard Daxon is manager.

NEBRASKA

OMAHA.—The L. V. Nicholas Oil Company is having plans prepared for the construction of a large new refinery, to have a capacity of 1,000 barrels daily. The company has awarded a contract for the construction of a new 100,000 gallon tank to be located on property recently acquired at Twenty-fourth and Hickory Streets, comprising approximately nine acres.

NEVADA

MINA.—Frank Manson, connected with the Western Ore Purchasing Company, has acquired the old Candelaria silver mine, and is planning for the construction of a new 150-ton mill.

NELSON.—The Allard Mining Company is planning for the installation of a new tube mill and centrifugal amalgamator at the Carnation mine, for the treatment of high-grade ore.

NEW MEXICO

MOGOLLON.—The Socorro Mining Company has commenced the construction of its main mill building at its plant. Immediately upon completion of the structure, machinery will be installed, deliveries of which have started.

NEW JERSEY

NEWARK.—The Central Dyestuff & Chemical Company, Plum Point Lane, is having plans prepared for the construction of a nef reinforced-concrete addition to its plant. Marshall N. Shoemaker, 810 Broad Street, Newark, is architect.

NEWARK.—The Mono Service Company, Verona Avenue and Oraton Street, has taken out a building permit for the construction of a new brick factory, to be used as an addition to its paper products manufacturing plant. The works will cost about $15,000.

NEWARK.—The Heller & Merz Company, Hamburg Place, manufacturer of chemicals, etc., has had plans prepared for alterations and improvements in its plant.

NEWARK.—Fire, on March 24, caused by an explosion, destroyed three buildings at the plant of the Butterworth-Judson Corporation, Avenue R, manufacturer of chemicals, with total loss estimated at $200,000. The company is working on large Government contracts.

EAST ORANGE.—The Dunbar Sulphur Candle Company has filed authorization papers to operate at 65-67 Midland Avenue for the production of sulphur candles. William C. Lentz, 247 Clinton Avenue, West Hoboken, heads the company.

PLAINFIELD.—The Crescent Color Company, West Front Street, manufacturer of dyestuffs, etc., has commenced the construction of a new addition to its plant. The structure is estimated to cost $20,000.

MILLBURN.—Fire, on March 27, partially destroyed the plant of the Fandango Paper Company, Main Street, with loss estimated at $10,000.

TRENTON.—The Panther Rubber Manufacturing Company, of Stoughton, Mass., has recently purchased a factory building at the foot of Perrine Avenue for a consideration of about $25,000, and is planning to remodel and equip the plant for the manufacture of its products.

CAMDEN.—R. M. Hollingshead & Company, Ninth and Market Streets, manufacturer of soaps, greases, etc., have had plans prepared for the construction of a new three-story brick addition to its plant, about 60 x 150 feet, to cost $10,000.

NEW YORK

NEW YORK.—The Consolidated Metal Manufacturing Company, 130 Washington Place, has had plans prepared for the construction of a new one-story brick chemical manufacturing works to be located at Gold and Tillary Streets, Brooklyn.

NEW YORK.—The Central Smelting & Refining Company, 220 Rider Avenue, has filed plans for the construction of a new factory building, to be located in Canal Street, near Dairymple Avenue, Woodhaven, L. I. The estimated cost of the structure is $25,000.

NEW YORK.—The Knowles-Bradley Company, 88 Wall Street, refiners of saltpetre, has awarded a contract for the construction of a new five-story brick plant, about 100 x 165 feet, in Coffey Street. The works will cost about $36,000. H. G. Larzelere, Sycamore Park, New Rochelle, is the contractor.

COLLEGE POINT, L. I.—The L. W. F. Engineering Company, manufacturer of aeroplanes, has recently filed plans for the construction of a new one-story brick addition, about 210 x 250 feet, to its plant at Third Avenue and Eighth Street. Contract for the structure, which will cost about $15,000, has been awarded.

MOUNT VERNON.—The Triplex Safety Glass Corporation of America has acquired a tract of seven acres of land along the New York, New Haven & Hartford Railroad, for a consideration said to be $80,000, as a site for the construction of a new glass plant.

BUFFALO.—Fire, on April 2, caused by an explosion, destroyed a portion of the plant of the National Aniline & Chemical Company, Abbott Road, with loss estimated at $50,000.

OHIO

CLEVELAND.—The General Chemical Company, Warner Road, has awarded a contract for the construction of two new additions to its plant to cost about $20,000. A. A. Lane Construction Company, 1836 Euclid Avenue, Cleveland, is the contractor.

CLEVELAND.—Fire recently destroyed a portion of the plant of the Lennox Chemical Company, which was engaged in the manufacture of anesthetics for the American Red Cross. Quantities of acids and gas being manufactured for the Government were also destroyed. The loss is estimated at $100,000.

CLEVELAND.—The Lake Erie Smelting & Refining Company has filed plans for the construction of a new foundry addition to its plant at 3363 East Seventy-fifth Street. The structure will cost $18,000.

MASSILLON.—The plant of the Massillon Electric & Gas Company was partially destroyed by fire on April 3, with loss estimated at about $250,000.

NEWARK.—The Holophane Glass Company has awarded contracts for the erection of a large new experimental plant on Oakwood Avenue, comprising tank, lehr, and general factory buildings. It is expected that the plant will be ready for operation before the end of the summer.

SPRINGFIELD.—The Ohio Steel Foundry Company is planning for the construction of two new additions to its plant near Lagonda one to be one-story about 30 x 120 feet, to be used as a core room, and the other about 30 x 100 feet, to be used as a blast and repair shop. A new electric furnace will also be installed, of three-ton capacity.

OKLAHOMA

ELK CITY.—The Lucky Elk Mining Company has completed its organization plans, and will commence the development of about 40 acres of lead and zinc lands recently acquired.

PICHER.—The Picher-Oklahoma Mining Company is planning for the immediate construction of a new 800-ton mill at its properties. R. P. McReynolds is general manager.

PICHER.—The Crystal Mining Company is planning for the construction of a new 250-ton mill at its properties. B. B. Dancy is president.

OREGON

GRANTS PASS.—The Almeda Mining Company has awarded a contract for the construction of a new reduction plant at its copper-gold mine on Rogue River, near Grants Pass, the concentrator to have a capacity of 200 tons, and the blast furnace being of 150-ton capacity. The estimated cost of the plant is $200,000.

PENNSYLVANIA

GLENDON.—Fire, on March 25, destroyed a portion of the fertilizer plant of Berger Brothers, with loss estimated at $10,000.

PHILADELPHIA.—The Brown Instrument Company has just let a contract to R. C. Ballinger & Co. for an addition to its factory to cost approximately $50,000. This addition will be erected on the land which was purchased last fall at Wayne and Roberts Avenues, adjoining the present building.

PHILADELPHIA.—The Powers-Weightman-Rosengarten Company, manufacturer of chemicals, etc., has awarded a contract for the construction of a new one-story brick addition, about 45 x 60 feet, at 921-27 Brown Street.

PHILADELPHIA.—Charles Lennig & Company, Inc., 112 South Front Street, manufacturers of acids and chemicals, have had plans prepared for the construction of a new machine shop addition to their plant at Bridesburg, near Philadelphia, to cost about $17,000.

PHILADELPHIA.—W. H. & F. Jordan, Jr., Inc., 218 North Delaware Avenue, manufacturer of chemicals and allied products, has acquired the building at 124 Water Street, New York, for the establishment of a branch selling office. The new branch will be in charge of Warren E. Monroe.

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The American Electrochemical Society and the South

THOSE who were fortunate enough to attend the National Exposition of Chemical Industries in New York last fall must have been struck with the exhibits made by Southern cities, railroads and industrial organizations. The impression was gained that not only was the South coming to the front, but that it had much to offer in substantiation of its claims for recognition. The material resources of the region were strikingly displayed, and there was tangible evidence that the South possessed and could produce a number of minerals that were much needed in this country, especially after the war disturbed foreign commerce.

We are inclined to suspect that those exhibits were real factors in the decision of the directors of the American Electrochemical Society to hold the next meeting in the South. Former invitations had not been lacking from this hospitable region, but always there seemed more pressing reasons for meeting elsewhere. This year, however, there could be no more appropriate combination, and since the decision was reached, the conviction has grown that no mistake was made.

The exigencies of war are bringing to fruition some of the cherished plans which Southern scientists and engineers have been trying for years to bring to the serious attention of the country. Confident that their region was destined to play a large part in national industry as well as in agriculture, and knowing the resources of mineral wealth and water power with which the South is favored, they were, nevertheless, unable until recently to impress the nation with the vital facts. Happily the deferred recognition is now at hand and those who have labored are to secure their reward.

No body of scientists and engineers is better able to appreciate the South's potentialities than is the membership of the American Electrochemical Society. Skilled in applying the electric current to metallic and non-metallic minerals, these gentlemen view broadly the fields of electrochemistry and electrometallurgy. They are interested in raw materials and electric energy, and since hydroelectric power offers certain marked advantages for their processes, they have a double interest in a territory that offers the combination of mineral wealth and water power. The South may well feel that in receiving this body of men and displaying to them her wealth, she is making valuable friends as well as entertaining appreciative visitors.

We have been glad to make an effort to serve both the Society and the South by presenting in this issue a summary of Southern resources contributory to electrochemistry and metallurgy. For the numerous contributions that make up the whole story, we are under

obligation to many busy men who responded to our request for coöperation. We believe the result justifies their efforts. We have here the background for a story that will be written in the future, a romance of industry in which will be woven the mineral resources, water power and engineering talent of a hospitable and chivalrous people.

Expanding Program of Nitrogen Fixation

IT HAS frequently been remarked during the course of the war that the United States is slow to get started, but once under way she will acquire a terrific momentum that will carry her through to a successful finish. The nitrate program is a case in point. For years a few knowing persons have preached nitrogen fixation in season and out, recognizing its importance to the nation in times of peace, to say nothing of its essential nature in war. But the words have fallen on deaf, or at least unappreciative, ears. Even within the period of the war there has been a failure to realize how largely we should go into nitrogen fixation, and our apparent needs now exceed by several times the most radical predictions of a few years ago.

The full program thus far announced is as follows: Plant No. 1, using the General Chemical Company's ammonia process, was built and will be operated by the Government at Sheffield, Ala. Plant No. 2, using the cyanamid process, is to be built and operated for the Government by the Air Nitrates Corporation, at Muscle Shoals on the Tennessee River, near Sheffield. Plant No. 3, according to a recent announcement credited to the War Department, is to comprise two units, located at Toledo and Elizabethtown, O. It is understood that Plant No. 4 also is to be built in the near future but the location is not yet decided upon. The two units of Plant No. 3 will have a combined capacity equal to that of Plant No. 2.

Although the location of the plants near Muscle Shoals on the Tennessee River was undoubtedly determined by the proposed hydroelectric developments there, it will be necessary to erect steam-electric plants for immediate use. Plant No. 1 will be served by the Alabama Power Co., which is now erecting a steam plant of twelve 1200-hp. Stirling boilers. Plant No. 2 will have twelve 1500-hp. boilers and two turbo-generators, one of 60,000 and the other of 7500 kw.

Truly we have been slow to get under way, but once started we are undertaking things largely. Some day the whole story will be written and it will make interesting reading.

Light in the Offing

THE appointment of John D. Ryan, president of the Anaconda Copper Co., as director of the aircraft program will be hailed with satisfaction and delight by the engineering fraternity of the country. Signs are multiplying that the Administration is profiting by the criticism of former appointments and is taking heed of sound advice and counsel. Following closely upon the announcement of the appointment of Charles M. Schwab to direct our shipping program, and Edward R. Stettinius in charge of purchasing for the War Department, the reorganization relating to aircraft production brings additional light and reassurance. Stettinius, Schwab and Ryan are synonomous with achievement and accomplishment, and are the type of men who have done things in a large way in business. We need more of their class in the conduct of the war, and it is to be hoped their number will increase. If the proposal to establish a minerals administration is carried out, it will be necessary to find a capable man to direct the work, and another opportunity will be given to make a wise selection. Some time ago when a Congressional committee reported on its investigation of delay in aircraft construction, it criticized the Administration for a policy of holding aloof from men who had special knowledge of certain branches of industry. The criticism was sound. Whether there has been distrust and suspicion of so-called big business, we do not know, but there is no doubt that we have lost immeasurably in time and production by failing to take advantage of that peculiar ability that has created and directed our largest industrial enterprises. No other nation has conceived and executed industry on such a huge scale. We have talent in abundance and variety, and of unquestioned patriotism. In our judgment it is the duty of the Administration to avail itself of such ability.

The Trend Toward Electric Brass Melting

READERS of this journal a decade and a half ago will recall that the rôle of the electric furnace in iron and steel metallurgy was then regarded as one of the most fascinating problems. Much speculation was indulged in regarding the future, but it was considered a safe prediction that the manufacture of special steels would be the line along which the electric furnace would make a successful bid for recognition. How complete that recognition has been is a matter of several years' record, for not steel alone, but pig iron as well has flowed from the electric furnace.

More recently the onward march of metallurgy has taken the electric furnace into the domain of brass melting, and the conquest bids fair to be complete. The main reasons underlying the economic change now taking place from fuel-fired to electric brass furnaces are to be found in the conservation of time, metal and fuel, improvement in the sanitary conditions of the foundry, and excellence in the strength and uniformity of alloys. The metallic loss, especially of zinc, is said to be lessened by at least one-half. With a thermal efficiency averaging perhaps seven times that of a fuel-fired furnace, the electric furnace affords a great saving even when using current from a steam-electric plant. With hydroelectric current the saving is infinitely greater. The saving of time and labor per unit of production is of material moment, especially under present industrial conditions.

There are on the market today over a dozen different electric furnaces for non-ferrous metallurgy, representing five different types, viz., induction, radiating-arc, direct-arc, resistance, and high-frequency. These are used for the production of a variety of metallic alloys which may be classified substantially as follows: (a) yellow brass with less than 3 per cent lead; (b) red brass and bearing-metal irrespective of the lead content; (c) red brass with low lead content; and (d) the aluminium mixtures.

The induction furnace is the type hitherto found most suitable for melting yellow brass with a spelter loss of one per cent or less. This is due to that characteristic of the induction furnace which permits accurate heat control, with consequent uniform temperature throughout the bath of metal. The advantage is obvious if it is desired to keep the volatilization of zinc at a minimum. Just recently the U. S. Bureau of Mines has perfected a new radiating-arc furnace which is said to be particularly suited to brass melting.

Class (b) alloys mentioned above are best melted in a furnace having a plain solid bottom devoid of all complications so that any lead which finally gets into the refractory hearth can do no harm even though it breaks through. The radiating-arc or the high-frequency furnace suggest themselves here and the former is thus much used and to some extent also the direct-arc furnace. The high-frequency furnace has not yet made its commercial appearance although it should fit in well in the non-ferrous industry, provided the cost can be brought reasonably low. Class (c) alloys give the least trouble, with comparatively low zinc content and little lead. The induction furnace lends itself to the production of red brass with low lead, less than three per cent; otherwise experience has shown that the lead may at any time percolate through the lining and damage the transformer coil. Class (d) alloys or high aluminium mixtures are formed readily with low loss in the resistance and radiating-arc furnaces. As far as known, these furnaces only are employed in this way commercially. High-nickel alloys are melted by all of the furnace types mentioned, and the best has yet to be determined. In general that furnace is being employed which gives not only the best metallurgical results, but which has also the simplest construction. Unfortunately these two features are not always coincident, as evidenced by the induction furnace which gives splendid results with yellow brass, yet its construction can hardly be called simple. Outside of the bottom-electrode type of furnace, all of the other electric furnaces which have reached the commercial stage are of fairly simple design and rugged construction.

Broadly speaking, the trend toward the electric furnace in the manufacture of brass and other alloys was heightened by the very poor sanitary conditions prevailing in many foundries where coke or oil furnaces polluted the air which the operators had to breathe. As the air remains clean with a properly chosen electric furnace, this characteristic alone was sufficient warrant for the investigation of electric melting devices. Other advantages have been found with later experience. The saving in labor is marked and the ability to keep experienced workers is pronounced. It is possible to keep better and more accurate records, have better technical supervision, turn out larger heats free from oxidizing influences, with almost absolute heat control and a very high thermal efficiency, approaching 80 per cent. All of these things observed in practice have so far induced the producer of non-ferrous alloys to install in the United States alone over 50 electric furnaces of different types, all of which are now operating and giving satisfaction to their owners. Plainly the trend is toward electric melting and the superiority of the electric furnace seems to be an accepted fact.

Will Dollar Silver Increase Production?

SEVERAL years ago it seemed that an enhanced price for silver was inevitable, since the rapidly expanding volume of the world's business was accompanied by only a moderate increase in the production of the precious metals, the shipment of gold and silver, of course, being the manner by which international credit balances could be leveled. The use of silver as a medium of international exchange received a powerful stimulus when Great Britain and the United States under war exigency embargoed the export of gold for this purpose except to certain governments. Enormously increased quantities of silver have therefore been exported from America to the Orient during 1917; China receiving twelve million dollars worth, double the quantity of 1916, and India absorbing $24,400,000, an increase of twenty-two millions. Add to this the quantities of metal coined to pay Allied troops, and the increasing amounts used in the arts, all producing an undoubted shortage of spot silver, which caused a continued rise in the price, rapidly culminating at $1.085 on Sept. 21, 1917. Cancellation of many orders on this runaway market caused a sharp recession, but the underlying demand must ultimately reappear. At the present time silver cannot be exported except under license; therefore there is no open market, and the price is held down by the lack of governmental purchases.

That Congress can act expeditiously when it so desires is shown by the fact that Senator Pittman's bill "to conserve the gold supply of the United States; to permit the settlement in silver of trade balances adverse to the United States; to provide silver for subsidiary coinage and for commercial use; to assist foreign governments at war with the enemies of the United States; and for the above purposes to stabilize the price and encourage the production of silver," was passed by both houses in short order. Debate in the Senate brought out the fact that the proposal "to assist foreign governments at war with the enemies of the United States" was the biggest factor in the whole plan, resulting from a demand by India against "the most important ally of the United States," Great Britain. Of the 350,000,000 silver dollars which are to be melted for export, Senator Owen admitted that the United States needed 50,000,000 "to take care of our jute from India alone."

The *modus operandi* of the bill as passed is as follows: The Treasury will remelt from its stock of nearly 500,000,000 ounces, 350,000,000 silver dollars, withdrawing the corresponding silver certificates from circulation and replacing them by an issue of Federal Reserve banknotes secured by United States gold notes. The mint will then proceed to re-stock the vaults by purchase of all available silver as fast as it is produced at $1.00 per ounce, again replacing banknotes by silver certificates.

Stabilization of conditions in Mexico would do much toward relieving the existing silver shortage, since in normal times she produced considerably more silver than the entire United States. However, this is apparently too much to ask; there is even little assurance that the estimated annual production of about thirty million ounces will materialize.

It is even doubtful that dollar silver will largely in-

crease the United States production beyond the present rate, which has been approximately stationary at seventy-four million ounces for the last three years despite the large increase in the market price. This idea is reinforced by a brief consideration of our present supply. About one-quarter of it comes from the refining of blister copper, which has enjoyed a fair price during 1917. As a consequence no sudden expansion in production of the red metal is to be expected. Another twenty-five per cent of the silver produced in the United States comes from the gold and silver mills. Here the full effect of the added price will undoubtedly be felt immediately in stimulating the output of the cyanide districts of Nevada and elsewhere.

The remaining production (practically half of the whole yearly output) comes from lead and lead-zinc ores. In this most important division, expansion of silver production will be much hampered by the divergent interests of the miner and smelterman. A large price for silver will tend to stimulate silver mining, but the lead smelters will continue to decline large increases in ore shipments. The smelter schedules are usually written so that the charge for treatment is assessed by paying the miner about four cents for the recoverable lead. If the lead market is high, the smelter profits. If the lead market is low, as at present, the largely increasing cost of labor, coke and usual repairs wipes out any balance on the smelter's books. Consequently, until lead prices advance in the face of increasing production, or ore contracts are rationalized, no great incentive for the smelters to increase their output of base bullion is apparent.

Iron and Steel in the South

"I WILL not say that Birmingham will furnish the world with iron, but I will say that she will eventually dictate to the world what the price of iron shall be."

The words are those of Sir Lowthian Bell—father of the present Sir Hugh Bell—on the occasion of the Iron and Steel Institute's memorable visit to the United States in 1890. Things move rapidly in the iron and steel industry, and if the prediction was to be fulfilled it ought to have been realized long ere this.

Not that Birmingham has done nothing. The state of Alabama, which is really not the whole of the Birmingham district, produced 2,953,705 gross tons of pig iron in 1917, making a new record, when most districts fell behind their output of 1916. Alabama's 1917 production was 32 per cent of the tonnage the whole country produced in 1890, when the prediction was made, and 37 per cent of Britain's production in that year, but Alabama's contribution to the pig iron output of the United States was 8.9 per cent in 1890 and only 7.6 per cent in 1917, showing a decline of 15 per cent in the proportion.

The prophecy, however, related not to tonnage but to price. As to price, it is well recalled that in 1897 Birmingham sold pig iron at prices that made producers in other districts, at home and abroad, stand aghast. The average market quotation on southern pig iron at Cincinnati in 1897 was $9.33. The freight rate from Birmingham to Cincinnati was $2.75 to May 1, 1917, and $2.25 thereafter, and allowing for this the average quoted price at Birmingham furnace would apparently be $6.91, but the computation is misleading, in that in those days freight rates were cut. On the other hand, sales were made, particularly for export, at under the quoted market, and thus it is probably not far wrong to say that Birmingham pig iron sold in 1897 at an average price of $7. Exports from the United States in that year were 262,686 tons, a large part of the iron coming from the Birmingham district. Incidentally, the present government price is $33.

Birmingham was not dictating, but was being dictated to. Furnaces lost money, and if their books did not show it the fault was in the accounting. The fates, however, had been against Sir Lowthian Bell in his prophecy of 1890. After the Institute meeting in Pittsburgh the visitors toured the country. They were in the Lake Superior iron and copper region October 15 to 18, and shortly afterward they returned home. No sooner were they safely out of the country than Alfred and Leonidas Merritt, on November 16, 1890, discovered the Mesabi range. Two years later the first Mesabi ore was shipped. The story of the range is familiar. By simple stripping operations enormous quantities of exceptionally rich ore were obtained, and it was literally sold as cheap as dirt in 1897.

There are many remarkable facts about the American iron and steel industry. Two of them are: (1) No large fortunes, made on the outside, have ever been put into the industry, except perhaps in certain isolated cases when the money was lost in unsuccessful experiments; (2) Until shares in the industry were mobilized by being listed on the stock exchange, practically no large fortunes were taken out. Yet the industry has made enormous sums of money. The deduction is obvious. Throughout its growth it has required the investment of great sums of money. The investments have very rarely been successful except when made by those who made the money in the industry, and without large earnings for reinvestment the manufacturer could not maintain the pace.

In 1897 the South sold pig iron at phenomenally low prices, and lost money. At the same time the Carnegie Steel Company sold steel at phenomenally low prices, and made money. For a time it borrowed from nearly every bank in Pennsylvania. The Southern producers could not borrow in their banks.

The Mesabi range rose and fell. The ores it is now shipping are very much less rich than those which made its reputation, for those rich ores are exhausted. With all the refinements, transportation costs are high. The Southern ores are as good as they were, and as years pass the competitive position, as regards quality of ore and coke, will improve for the South. Capital it certainly will be able to command much more freely than hitherto. Labor conditions in the United States produced by the war necessitate that in the future there must be much wider use of labor-saving machinery than there has been in the past. That probably will be to the advantage of the South, where inefficiency or scarcity of labor has exerted a restrictive influence. The South still has the natural advantages upon which Sir Lowthian Bell based his prediction. If the Mesabi range had not been discovered the course of American iron and steel development in the intervening 27 years might have been quite different.

Readers' Views and Comments

Electrochemical Industry Essential to Winning the War

To the Editor of Metallurgical & Chemical Engineering

SIR:—The United States is now training over a million men to fight in France. Several million more will be trained. These men must have cannon, machine guns, rifles, shells, powder, cartridges, gases, airplanes, automobile trucks, and all other equipment of war in enormous quantities.

To manufacture these munitions high-grade alloy steel is necessary. For the preparation of the ferro-alloys used in making this steel existing electric furnaces are being worked to their utmost capacity. Numbers of new electric ferro-alloy furnaces are being constructed.

The vast quantities of abrasives which are so essential for the manufacture of machine guns, rifles, shells, automobile trucks, airplanes and all other machinery are almost all prepared in the electric furnace. In fact were it not for the electric furnace production of abrasives, it would be possible to produce only a small fraction of the vast amounts of machinery equipment for war purposes which are being turned out daily. The average man, unless he stops to consider the present manufacturing situation, has little or no conception of the fact that almost all fine machine work nowadays is finished in the grinder or with the use of abrasives.

For the manufacture of airplanes and auto trucks vast quantities of aluminium are required. This can only be manufactured by electrochemical processes.

Large quantities of the zinc necessary in manufacturing the brass used in the millions of cartridge cases made daily are recovered from the ore and purified electrolytically.

Many of the gases used for war purposes, i. e. hydrogen, chlorine, and bromine, are largely possible of preparation only by electrochemical means.

Many of the nitrogen compounds used for preparing the vast quantities of explosives required by our army and navy will be prepared with the aid of electrochemical and electrothermal processes.

Other basic materials such as magnesium, graphite, carbon electrodes, potassium chlorate, etc., which will be required in quantities can only be prepared with the aid of the electric furnace or electrolytic cell.

It is self evident to every thinking man that the electrochemical industry is essential to the winning of the war.

The war has resulted in a tremendous increase in interest throughout the country of all subjects having to do with chemistry and electrochemistry. The memberships of the scientific societies dealing with these subjects have increased tremendously. In view of these facts I think that your journal can well afford to emphasize the importance of the electrochemical industry to the country at large and also the fact that the interests of the electrochemical industry and the Electrochemical Society are identical, for in the Electrochemical Society are associated the men of the country who are pushing forward this work. Membership in the society affords the opportunity to stand shoulder to shoulder with the men, who foremost in their profession, are making it their business to see that the United States and her Allies receive the very best possible support from the electrochemical industry and all others related thereto.

The American Electrochemical Society is recognized as one of the livest scientific organizations in existence and is nationally renowned for the breadth of the discussions covering the papers and addresses presented at its two general meetings held each year in various parts of the country, which, combined with visits and special excursions to the more important centers of electrochemical developments are attended by the foremost electrochemists, engineers, metallurgists, chemists, manufacturers and central station men.

In existence for the past sixteen years, its membership of approximately two thousand extends throughout the entire world. Its literature is recognized as the only complete journal or "hand book" extant on the subject of electrochemistry. Its membership is open to those engaged in, affiliated with or interested in any way in electrochemistry and allied subjects.

The president of the society is Dr. C. G. Fink, well known for his development of the ductile tungsten used in the modern incandescent mazda lamp, and at present in charge of the research laboratory of the Chile Exploration Company.

The general secretary of the society is Dr. Joseph W. Richards, Professor of Metallurgy, Lehigh University, South Bethlehem, Pa., who as a member of the Naval Consulting Board is spending a large part of his time in Washington assisting with the work of this body, which by the way numbers among its members four past presidents of the American Electrochemical Society.

CARL G. SCHLUEDERBERG.

Westinghouse Electric & Mfg. Co.,
E. Pittsburgh, Pa.

Electrolytic Pickling of Steel

To the Editor of Metallurgical & Chemical Engineering

SIR:—In your issue of March 15 Dr. Carl Hering makes some criticisms of work by Mr. Dodson and myself which appeared in your Dec. 15th issue, on Electrolytic Pickling of Steel. I should like to reply briefly to these remarks.

Dr. Hering's first criticism is that the chemical pickling did not last long enough, thus dissolving less iron than would normally be dissolved. In a former article[1] the object was to carry out the process in such a way as to make the electrolytic method appear to the best advantage; in this article, to the least advantage, as stated in the first paragraph, with the idea that actual practice would lie within these limits. For this reason the pickling was not continued beyond the point stated, where the scale was all removed except some very fine particles that could be completely cleaned off by brushing.

[1] Tr. Am. Electrochem. Soc 31, 181 (1917).

The second point is that in the chemical pickling the scale was filtered off before titrating the iron dissolved. In the first article all scale was dissolved before titrating; in this, none. In practice the results would lie between these two extremes.

The third criticism is that the acid was stronger than what Dr. Hering understands is used in practice in acid pickling, and not as strong as the patent calls for in the electrolytic pickling. Patent No. 827,179 states "good results" may be obtained with acid between specific gravities 1.15 and 1.25. Patent No. 855,667 recommends specific gravity 1.2. We used 1.19. I understand that 4.5% acid is used in chemical pickling. It was perfectly proper to use the strength that gives the best results in this comparison. This criticism is therefore entirely unjustified.

The fourth point is that the current density was not as high as called for by the patent. The patent (No. 855,667) calls for 40 to 70 amperes per sq. ft. Our current densities varied from 0.033 to 0.058 amperes per square centimeter or 30 to 54 amperes per square foot, averaging over 40 on the ordinary black plate; higher for the silicon-steel plates. This is within the limits specified by the patent. Dr. Hering's statement that the electrolytic process was not carried out properly is therefore not true.

Finally I believe these two investigations show the electrolytic method superior to the chemical method, and that this superiority increases with the thickness of the scale treated.

M. DE KAY THOMPSON.

Cambridge, Mass.

Electrolytic Pickling of Greasy Surfaces

To the Editor of Metallurgical & Chemical Engineering

SIR:—The question has frequently been asked whether grease or oil on the surfaces of the steel would interfere when the scale is to be removed by electrolytic pickling, and whether the pickling removes this grease also. It was thought that the oil, being an insulator, would first have to be carefully removed, as in electroplating.

The writer therefore made the following tests: A piece of ordinary sheet steel covered with black scale was used; before pickling and while quite dry, a small part was painted over with mineral lubricating oil; another part with soft tallow; another part with linseed oil; and another part with lard oil. These oils and the grease therefore represented mineral, animal and vegetable oils; in each case they were well rubbed into the surface. The rest of the plate was left free from all grease or oil.

It was then pickled electrolytically in the prescribed way, by the Reed process, and it was found that the scale was removed quite as perfectly and quite as fast from those parts of the surfaces which had been covered with oil or grease as from those which had not; the oil and grease had disappeared completely, and on the cleaned surface it was not possible to find any indications of which of the parts had been oiled. The test was repeated many times, always with the same result. The oil was put on in as thick a layer as would adhere to a vertical plate, and the tallow was put on thick enough to show white. One of the plates was removed for inspection every five seconds but there was no noticeable difference between the reduction on the oiled parts and on the others. It seems that the hot nascent hydrogen or the current itself removes the oil and grease very effectively.

On removing the plates the water did not seem to wet them, indicating that they got a film of oil on them from the oil which had gathered on the top of the bath; this is an advantage rather than otherwise; and presumably it would not interfere with the subsequent tinning as such tinning baths often have a layer of oil over them through which the plate must pass before entering the tin bath.

It follows therefore that oil or grease, no matter how thick the coating, does not interfere in the least with electrolytic pickling.

CARL HERING.

Philadelphia, Pa.

Analysis of Ferro-Silicon

To the Editor of Metallurgical & Chemical Engineering

SIR:—I am sending herewith a condensed method of longer standard methods for the complete analysis of ferro-manganese. I have been using this scheme of analysis for some time with very satisfactory results.

A one-gram agate-ground sample is dissolved in 30 cc. of concentrated hydrochloric acid with the addition of a few crystals of potassium chlorate, and the solution evaporated to dryness. Take up with dilute HCl and filter off the silicious matter. The filtrate is taken to dryness a second time to render the last traces of silica insoluble. The two precipitates are carried through the usual silicon analysis. To the filtrate add ammonium chloride and boil. Precipitate the iron with ammonia. Dissolve the precipitate in dilute HCl and re-precipitate the iron twice in order to render the last traces of manganese in solution. After the third precipitation and filtration dissolve the iron precipitate in dilute HCl and titrate the iron with potassium permanganate (N/10 solution). The combined filtrates and washings from the iron separation are made acid with HCl and brought to a boil; then add 15 cc. of a 25 per cent solution of sodium-ammonium phosphate. While the solution continues to boil and with constant stirring, precipitate by adding concentrated ammonia drop by drop until a silky white precipitate of manganese phosphate is formed, after which enough of the ammonia is added to make the solution faintly ammoniacal. Remove from the source of heat and allow to settle a few minutes. Filter on a weighed Gooch crucible, ignite and weigh as $Mn_2P_2O_7$. The factor for manganese in this compound is .3869. If there is an appreciable amount of residue left in the crucible after completing the silicon determination, it should be fused with fusion mixture and the manganese determined by the sodium bismuthate method. Any result so obtained should be totaled with the manganese percentage. The carbon content may be obtained by the usual combustion method.

M. A. MAMMEN.

Middletown, O

Further Hearings on Federal Water-Power Bill

SIR Adam Beck, chairman of the Ontario Hydroelectric Power Commission appeared before the special Congressional committee on water-power bills on April 15 and spoke for five hours on conditions in Ontario. The hearings before the special committee will not close until Secretaries Baker and Houston have been heard, and there is some delay in prospect before a final bill will be drafted and presented to Congress. Members of the House, however, express confidence in the passage of a bill at this session.

In his address to the committee, Sir Adam Beck traced the inception and development of hydroelectric power in Ontario, beginning with the granting of franchises to the Canadian-Niagara Power Co. for 100,000 hp.; the Electric Development Co. for 125,000 hp. and the Ontario Power Co. for 180,000 hp. In 1900 the Board of Trade of Ontario initiated a movement to secure development privileges for municipal purposes. This was not considered favorably by the legislature, but in 1902 an act was passed authorizing municipalities to borrow money for light and power development. Difficulties were encountered in raising money, and rights were granted to the Electric Development Co. which had affiliated with it the electric light and street railway companies of Toronto.

In speaking of the present hydroelectric commission of which he is chairman, Sir Adam said:

"We have power to acquire by purchase or otherwise, on any terms, and hold shares in any incorporated company carrying on the business of developing, supplying and transmitting electrical energy. We have power to appropriate the land, waters, water privileges or water powers or works, machinery and plants or portions thereof of any person owning or operating under lease or otherwise or operating or using water-power privileges or transmitting electrical power or energy in Ontario which in the opinion of the Commission should be purchased, acquired, leased, taken, expropriated and developed or used by the Commission for the purposes of the Act."

At the present time the Ontario commission has acquired about 86 corporations, all by friendly negotiations and without resorting to the drastic powers delegated for that purpose. Contracts are in force with 225 municipalities. The form of contract is standard in all cases; the municipality pays all interest charges at 4% and a sinking fund of 1.8% which retires in 30 years. They pay line losses, depreciation charges, cost of operation, administration, etc. The average cost of power delivered to 225 municipalities in Ontario is under $18 per hp. The average rate is 2½ cents per kw.-hr.

"We operate at the present time twelve systems. They will become interconnecting eventually and form one great trunk system. In this way we are attaining the object of the whole scheme, namely, unit control.

Believes in Monopoly of Water Power

"We want to create a real monopoly because we believe all these service undertakings should be a monopoly. There is little satisfaction in having competition in a telephone system, or a telegraph system, or even a railway system, and certainly not in an electric system in any community. The obnoxious poles and wires, the great dual cost of everything, and the great dual investment that results because of the diversity created by these various corporations covering the same field is undesirable from every standpoint."

As to the Niagara situation, Sir Adam said the principle laid down by the International Waterways Commission is that there should be an equal division of water for power purposes on all international streams, and pointed out that there is now pending an application that the United States Government shall confer with the Dominion authorities regarding a proposal to allot another 10,000 second-feet to each government. This, he pointed out, is advanced as a war measure, and will be justified even though the most efficient use is not made of the water. Sir Adam said he believes that if this measure is carried through it would not be canceled after the war, but that the allotments would be permanent. He presented figures to show that the total power now being generated on both sides of Niagara is 653,500 horsepower. Of this amount, 265,000 horsepower is generated in the United States, which also receives 110,000 horsepower exported from the Canadian side, making a total of 375,000 horsepower available in the United States. This amounts to 40 per cent. more for the United States than for Canada although the latter country generates 100,000 more horsepower than the United States.

Present Conditions Unfavorable to United States

Comparing conditions on both sides of Niagara with relation to the establishment of electrochemical industries, Sir Adam pointed out the necessity of stabilizing prices for the encouragement of industry and said that under present conditions he thought industries would be more likely to go to Canada than to the United States. He was strongly in favor of government control of water power and intimated that nationalized control on our side of Niagara would do much to foster electrochemical industry in the United States.

The chairman of the commission went on to say that there is no intention on the part of the Canadian government or on the part of the Commission to interfere with the present export arrangement, even though Canada is now short 100,000 horsepower of the amount that country needs. In order to permit a continuance of the export, Canada has arranged to do away with all sign lighting, window lighting, and other uses of energy which in some quarters have been characterized as less essential. He said the power generated by the Province of Ontario has reduced coal consumption between 5,000,000 and 6,000,000 tons per annum. Motive power has been saved, use of cars has been saved, and duty on coal has been saved. The estimated potential horsepower of hydroelectric energy in Canada, Sir Adam said, is about 50,000,000, and in Ontario alone about 5,000,000 or 6,000,000, with but 700,000 developed. At the beginning of the Commission's work, in 1910, only 750 horsepower was being delivered to the twelve municipalities.

Speaking of the purchase of the Ontario Power Co., Sir Adam said that the commission expected to own the plant in 25 years, paying for it out of revenue from contracts with municipalities and with the Niagara-Lockport Co. Present contracts are at $9 per horsepower for 100,000 hp., and at $12.50 with the Niagara-Lockport Co. for 60,000 hp.

Secretary Lane Urges Water-Power Development

The Secretary of the Interior Regards a Constructive Program as a Vital Necessity to the Conduct of the War as Well as for the Future Extension of Our Electrochemical Industries

IF THE Congress of the United States is willing to commit the country to a program of federal development of water powers I see nothing impracticable in government ownership and operation of such utilities," said Secretary Lane in an interview with METALLURGICAL AND CHEMICAL ENGINEERING on the water-power question. "But," he continued, "under present conditions it seems more likely that immediate results will be secured through private initiative, and inasmuch as the quickest possible development is needed for the benefit of our electrochemical and other industries, both for war and peace, I am in favor of encouraging such a program. Owing to the tremendous demands now being made on the Government for funds it would seem unwise to adopt a policy of government ownership at this time. On the other hand, since there is a genuine demand on Congress for hydroelectric development, it is the duty of the Government to lend every assistance and to pursue a policy of fair and reasonable treatment of those who are willing to take the risk of investing money in such enterprises.

FRANKLIN K. LANE

The opinion of Secretary Lane on this question was sought not only on account of the general importance of the subject, but also because of the Secretary's wide experience in the administration of water power and related projects in the Department of the Interior. Continuing he said:

"The electrochemical industries of the United States have been found particularly essential to the conduct of the war, and yet they have not had adequate power. If these industries are to be fostered in this country and their extension made possible, it will be necessary to provide more power; otherwise we are confronted with the expatriation to more favorable localities of those industries which should be established here. More power should be developed at Niagara, and I believe that the United States and Canada should enter into an agreement for a large international development there that will make one million horsepower available to both countries. It would seem quite as feasible to secure the necessary legislation for this purpose as to negotiate a new treaty allotting to each nation additional water for private development.

"It is not at Niagara alone, however, that we need to develop water power. Our program should encourage development throughout the country wherever there seems to be a necessity for it and wherever we have mineral resources contributory to electrometallurgical industries. Some time ago I had prepared by the Geological Survey a series of maps of the Southeastern United States, showing the mineral resources of that region. It so happens that this same territory is rich also in potential hydroelectric energy. Some of it is developed but more will be needed as our industries expand with the normal growth of the country. We should realize that we need to undertake these developments immediately to meet war needs as well as to provide for future expansion. We have already witnessed wonderful progress in our chemical industry since the war began, and I believe we are on the verge of still greater expansion which will put this country in the lead. Prudence and foresight dictate that we should develop our water powers *now* in anticipation of the industrial growth that seems right at hand.

"Our neglect of water-power development in the past has been absolutely criminal, and in our present emergency we are discovering what it would have meant to us to have a great national resource well in hand. At a time like this we need to throw every resource we possess into the balance, and we have been woefully lacking when it came to water power. Of course the conservation of coal is an argument for water-power development, because much of our coal is used wastefully, and once used is gone forever. We ought to conserve our coal and use it in such a manner as to recover all the useful chemical by-products. Coal that is adapted to making coke should be used for that particular purpose and not as ordinary fuel. Another argument is the need of hydroelectric power for transportation on railroads—a problem which even now threatens to become acute next winter with its attendant fuel troubles. But to my mind the logical argument for water-power development is the folly of allowing a great natural resource to run to waste when it might be made to contribute so much to our industrial prosperity in times of peace and our national security when threatened with war.

"I have been deeply impressed with the importance of the chemist and the electrochemist, both in peace and war, and I realize the value of their contributions in meeting the problems forced upon us in our present emergency. It has given me a glimpse of the expanding romance of those sciences, as well as a vision of what the future holds for this country if we develop our resources to the fullest extent."

Director Manning Shows Importance of Electrometallurgy

Director of U. S. Bureau of Mines Emphasizes Vital Relation Between Hydroelectric Development and Electrometallurgy. Sees Expansion in Future Application of Electricity to Metallic and Non-Metallic Minerals

IF one looks at the relief map of this or any other country he cannot but be impressed with the large area of the earth's surface which is covered by hills and mountains, and unsuited to agricultural purposes, as compared to that which is so suited. At first glance one gets the impression that this is opposite to what it should be; but if we take into consideration the fact that the agricultural land of the earth by judicious and careful attention, may be made to yield food products continuously from year to year, while our mineral deposits, if once worked out, are gone forever, we come to the conclusion that after all it is a wise provision of nature that the proportion of the hills and mountains to the tillable land is as it is. These same hills and mountains serve as storehouses from which may be taken as needed, the ores which furnish the iron and steel which is used in the construction of our railroads, our steamships, our great buildings, and our machinery of every sort. From these same hills come the ores of the rare metals used in giving steel its special properties; the copper so essential to the manufacture of our alloys, and above all to the transmission of the electric current which can be most readily generated by the power afforded by the cataracts and falls of the rivers and streams.

VAN H. MANNING

In this connection, it is also well to remember that this source of power is perpetual. Although our coal beds may be mined and consumed, and although our metallic resources may be depleted, the water power of the country is, except where affected by the destruction of the forests, as great today as when man first set foot upon the continent, and, so far as we are able to judge at present, should remain so until the end of time. Although man early learned to harness the power of the water-fall and put it to use, it was not possible until electricity had been discovered, and ways and means of transmitting it perfected, to utilize the power of the water-fall at any great distance from its source. As the science of electrical engineering was developed it became possible to transform the latent power of the mountain streams into electric power capable of being transmitted hundreds of miles to light our cities, propel the cars along the streets, turn the wheels of factories, and in general make modern life possible. Although the discovery of electricity and the application of electrical engineering has done all this for us, it has also made possible the conservation of our coal; in other words it has extended the life of our fuel resources, especially for mining and metallurgical purposes.

Naturally, I am particularly interested in its use for the latter purposes, due to the fact that one of the principal functions of the Bureau of Mines is to conserve our mineral resources. As is well known, the use of electricity is becoming more and more extended in metallurgical work. Moreover, as is also well known, the application of electricity to metallurgical processes is comparatively recent. It was not until 1882 that it was probably first used by Siemens in electrothermic work, and its first application on a large scale for electrolytic purposes was perhaps in 1886 by Heroult and Hall, who in that year patented their processes for the production of aluminium. As late as 1898 the work of Stassano in producing pig iron in an electric furnace was looked upon more as something spectacular than as forecasting the important part which the electric furnace was to play in metallurgical work in the future; and it was not until 1900 that ferro-alloys began to be produced in the electric furnace. Taking into consideration this fact, and also the fact that today practically all ferro-alloys are made in the electric furnace, and that there are now two or three hundred steel furnaces making the same high quality of steel that it was formerly thought could be produced only in crucible furnaces, one is impressed with the rapid growth of the use of the electric furnace in the ferro-alloy and steel industry.

Electrolytic processes also are finding a more extended application as evidenced by the growth of the electrolytic zinc industry. In this day and generation it is not safe to predict just what may or may not be possible; but judging from the rapid growth of the application of electricity to metallurgical work during the past 20 years, it would seem safe to prophesy that electricity is only beginning to be applied to winning metals and non-metallic products from their ores, and that it will not be long until electrical processes will be discovered and applied to the treatment of those ores to which they are not at present applied. This seems true especially in the southern part of this country, to be visited by the American Electrochemical Society.

Proposed Minerals Administration Bill

A Synopsis of H. R. 11259 for the Control and Administration of Certain Special Minerals With a Particular View to Stimulating Production to Replace Import. Reported Favorably to the House by the Committee on Mines and Mining

AS MANY of our readers are undoubtedly aware, the War Minerals Committee has deemed it wise and necessary to propose national legislation for the purpose of securing adequate supplies of certain minerals, hitherto largely imported, and now essential to the production of munitions or for war industries. Under the direction of the Department of the Interior and with the approval of Secretary Lane, a bill was prepared and introduced in the House. Subsequently, hearings were held on the bill by the Mines and Mining Committee, and a favorable report has been returned to the House. It is reported in Washington that the Senate is likely to propose a bill differing in important details from that of the House, and that further hearings will be held by the Senate Committee. There seems to be agreement on the purposes of the legislation, but disagreement as to the methods of accomplishment. For the information of the industry we give a synopsis and comment on the sections of the House bill as seen by its proponents. With but two or three exceptions, the hearings developed a favorable attitude toward the bill. Opposition developed to the feature of price-fixing and to the possible interpretation of the bill to include the ordinary metals of which some of the unusual metals are by-products. As a substitute for the plan proposed by the bill, it was suggested that the Government organize a mining corporation and engage in business for the purpose of securing needed metals.

In the face of higher costs, unstable prices, transportation congestion, labor problems, and new taxes, increased domestic production is not taking place at a satisfactory rate. The bill plans to meet this situation in two ways. First: To increase production by stabilizing market conditions and eliminating part of the risk due to the uncertainty as to the length of the war; and second: where domestic production is not possible, to control consumption and prevent waste and nonessential use.

No Governmental body now has the authority which must be exercised to stimulate domestic production and to control effective distribution and use of these mineral supplies. The bill has been modeled after the Lever Bill, under which the President formed the Food Administration. The circumstances which justified the passage of that act are almost identical with those which now threaten to reduce the supply of these essential minerals. The bill provides authority to encourage the production of ores and minerals and to conserve their supply, to assure equitable distribution, to improve and direct utilization, to prevent manipulation, speculation, unfair practices and unequal division of profits, and to lessen our dependence upon imported materials.

Section 1 enumerates the minerals and their products which are included under the jurisdiction of the bill and which are defined as "necessaries." The minerals included represent those which have been formerly imported and whose supply is now uncertain due to shipping conditions, and in addition certain special minerals for which the demand for military purposes may increase beyond our visible supply.

The bill specifically defines "only the following named mineral substances and ores, minerals, intermediate metallurgical products, metals, alloys and chemical compounds thereof, to wit: Antimony, arsenic, ball clay, bismuth, bromine, cerium, chalk, chronium, cobalt, corundum, emery, fluorspar, ferro-silicon, fullers earth, graphite, grinding pebbles, iridium, kaolin, magnesite, manganese, mercury, mica. molybdenum, osmium, sea salt, platinum, palladium, paper clay, potassium, pyrites, radium, sulphur, tin, thorium, titanium, tungsten, uranium, vanadium, zirconium, and of other rare elements."

Section 2 authorizes the President, through the Secretary of the Interior, to take such steps as are necessary to carry out the purposes of the act and to create the necessary organization for this purpose. In view of the fact that this work will be of temporary war emergency character and must be carried out with the greatest dispatch, it is provided that persons may be employed without reference to Civil Service laws and regulations, as has been done under similar administrations which have been created.

Section 3 prohibits the agents or employees of the Government who are engaged in the carrying out of the provision of this act from soliciting contracts or from taking part in the letting of such contracts where they may have any financial interest involved, and provides penalties for the same, and in addition the forfeiture of any profits accruing as result of any action taken contrary to the provisions of this section.

Section 4 is a general section making unlawful certain acts which are covered in detail in the succeeding sections.

Section 5 provides for the licensing of the manufacture, storage, mining, distribution, and use of the "necessaries" specified in the bill. The licensing power is one of the most effective and necessary instruments for carrying into effect the provisions of the bill. There is considerable latitude left as to the method of licensing so that it might be possible to license any branch of the industries concerned either by general proclamation or by the issuance of individual licenses to every concern. It is assumed that the licensing power will not be used except where necessary. Due to the limited number of persons or concerns engaged in the production and distribution of the minerals specified, the number of licenses will be relatively very small, and consequently this feature of the bill will not cause any great expense or difficulty of administration. For example:—There are not over a dozen producers of sulphur, less than a hundred producers of pyrite, and not over two or three hundred producers of manganese. The provision for entry and inspection by duly authorized agents is essential to secure the necessary information with regard to compliance with licensing provisions and information dealing with consumption and prices. Authority is given to determine and establish just and reasonable returns to the various parties concerned in the production and distribution of the minerals involved. It is designed to correct an unequal division of profits between miners, brokers, smelters, and manufacturers, in order to insure adequate prices to stimulate production and at the same time to prevent an undue enhancement of the prices of products to be consumed.

Section 6 defines hoarding as the accumulation of supplies in a quantity in excess of the reasonable requirements of the business or when accumulated for the purposes of manipulating prices.

Section 7.—Hoarding has been defined as an unlawful act and this section provides a method of procedure in cases in which hoarding has been committed. The power to requisition conferred in Section 10 does not infer that an unlawful act has been committed and there is no penalty attached. On the other hand, if hoarding has been willfully committed, the person may be guilty of a violation of the law and becomes subject to condemnation proceedings. The evidence of hoarding is a question of fact which must be determined by a court or jury.

Section 8 provides a penalty for the willful destruction of "necessaries" as defined in the bill.

Section 9 provides penalties for limitation and restriction of output. Since the purpose of the bill is to stimulate production, this Section is primarily designed to prevent willful limitation of the supply and will not, of course, apply to ordinary commercial factors which discourage production.

Section 10 authorizes the President to requisition "necessaries" when required for the successful prosecution of the war and provides the means for justly compensating the owner. The necessity for this section lies in the fact that essential industrial and military requirements must first be met and that persons must be prevented, where a shortage exists, from diverting their products to non-essential uses.

Section 11 gives power to buy and sell and to make contracts for periods of not exceeding two years. The inability of producers to secure long time contracts for their product has contributed more than any other single factor to hinder new development. Uncertainty regarding the duration of of the war and the trend of prices thereafter discourages investment in any enterprise which is primarily based on war demands. It is obvious that if the power of purchase is granted, the powers to provide storage facilities and to sell must naturally follow. As long a contract period as two years is deemed absolutely essential because of the time element involved in opening new mines which usually takes a minimum of from four to nine months. No new contracts can be entered into after the termination of the war.

Section 12 empowers the President to take over and operate mineral deposits and plants which are either idle or insufficiently developed. While this power should be used as a last resort, it must be available for emergency. Such, for example, as where a deposit cannot be operated because of litigation, where the owners might refuse to develop the property, or where, because of its inaccessibility, private capital would be unable to operate it. The primary purpose of the bill is to stimulate development of necessary minerals by private capital wherever possible. This section is necessary to take care of any case where the other methods of stimulation provided might fail and where the output was essential. The section provides for the return of such properties as soon as the war necessity is over and for just compensation for any damage or depletion which may occur.

Section 13 provides for regulations to prevent speculation, manipulation of prices and unfair or misleading market quotations related to the minerals enumerated in the bill, and provides penalties for willful violation of such regulations.

Section 14 grants power to establish a guaranteed price in order to insure a reasonable profit to the producer and thereby stimulate production. Such guaranteed price may be for a period of two years. Considering the time element necessary to develop new mines and plants, two years is only a fair and reasonable time. Any shorter period would fail to accomplish satisfactory results in many cases. Sufficient latitude is allowed through regulations which may be prescribed in the establishment of guaranteed prices to make possible a sufficiently flexible handling of the problem to secure the best results. This section provides that duties may be placed upon the import of "necessaries" sufficient to bring the price of the imported article to the same level as any guaranteed minimum price which may be established under the bill. This provision is put in the bill for the purpose of protecting the United States Government. The Government having once established a guaranteed minimum price must, to make it effective, purchase such ores as are offered at that price, for the period of the guarantee which may be two years. In case of a sudden ending of the war, foreign "necessaries" might be imported at lower prices, unless this provision were made, thereby compelling the Government to purchase all domestic material at the higher guaranteed prices and increasing the liability of the Government to this extent. This Section further provides the power to fix prices. The establishment of a guaranteed price is essential to stimulate production, but additional price-fixing powers are necessary in order effectively to secure reasonable prices in any intermediate transactions between the producer and consumer. The section further provides that rules and regulations can be established with regard to methods of conducting business as supplemental to the licensing powers granted under Section 5. The necessity for control over methods of manufacture arises out of the possibility of a change in raw materials, or a scarcity of certain kinds of raw materials, or the use of substitute materials, which may require a change in practice. For example, in the steel industry it may be essential to revert to former practice and extend the use of the lower grade manganese alloys in place of the higher grade alloy formerly used which requires higher grades of ore than many of our domestic deposits will furnish.

Section 15 authorizes the curtailment of non-essential uses of the minerals covered in this bill in case a shortage of supply occurs which necessitates such action. For example, under this section it would be possible to prohibit the use of platinum in jewelry, or stop the use of tin for containers of dry substances.

Section 16 imposes a penalty for resisting an officer or employee enforcing the provisions of this bill.

Section 17 provides an appropriation of $500,000 for the administration of this Act.

Section 18 provides an appropriation of $50,000,000 to carry out the general provisions of this Act. This $50,000,000 is, in fact, a working capital which will enable the Government to enter the market and buy and sell the mineral products specified and to purchase any material which may be offered under the guaranteed prices established. This sum is not too large for the purpose, in view of the large liabilities which might be assumed under the bill. The value of the mineral products involved in the bill would be, at least, several hundred million dollars. While it is not contemplated that it will be necessary for the Government to actually purchase any considerable amount of the products whose prices may be guaranteed, a sufficient fund must be available to meet any possible contingency.

Section 19 provides that no employee under this Act is exempt from the provisions of the draft law.

Section 20 provides for annual reports of work done and details of expenditures.

Section 21 provides that if any part of the Act be declared invalid, such judgment shall not affect any other part of the Act.

Section 22 relates to the interpretation of the Act.

Section 23 provides for the termination of the provisions of this Act as soon after the close of the war as, in the judgment of the President, the agencies created can cease their activities and turn business back into its regular channels. While it is provided in Section 11 that no new contracts can be entered into after the termination of the war, it is obvious that it will take some time to settle the liabilities which may be contracted under the provisions of the bill and that consequently some organization will be required to terminate such business.

Bunker Hill Smelter Suits Ended

The suit filed last fall by the American Smelting & Refining Co. against the Bunker Hill & Sullivan Mining & Concentrating Co., and reviewed in our issue of Oct. 15, 1917, has finally been settled. Justice Wolverton at Portland has granted the preliminary injunction asked by the A. S. & R. Co., prohibiting the Bunker Hill company from smelting any of its own ores containg between 30 and 70 per cent lead. According to Stanley A. Easton, general manager of the Bunker Hill company, the adjustment provides for the future of this company. By its terms the ore produced will be divided equally between the two companies. Under the terms of the old contract the A. S. & R. company received ore containing 30 to 75 per cent lead, and the Bunker Hill retained ore having higher and lower contents. About 7500 tons a month will be available for division under the terms of the new agreement. The old rates charged by the A. S. & R. company have been readjusted so that the Bunker Hill will receive payment for a full 90 per cent of the lead content based on New York quotations and the grade of ore instead of the usual Coeur d'Alene contract, which provided for a split in price above $4.10 to the 100 pounds. The documents have been signed and the new arrangement will become effective at once. The suit will be dismissed if it has not been so disposed of.

SITE OF DAM NUMBER THREE, MUSCLE SHOALS

Nature's Gift to the Electrochemist at Muscle Shoals

By WILLIS G. WALDO

AFTER a ten years' struggle with the obstructionists and pseudo-conservationists, the 660,000 horsepower which since the dawn of the present geological era has been running to waste in the Tennessee River is about to be developed. That ten years should have been required to secure the development of this power is evidence which points with great emphasis to the difficulty of bringing fundamental economic truths to the intelligent understanding of the busy business man. If, for example, the city of New York could witness a 100,000-pound capacity car fully loaded with coal taken to a prominent dock and dumped into the Atlantic Ocean, could see this carload of coal followed by a similar car ten minutes later, and could see this performance repeated at ten-minute intervals thereafter, continuously, day after day, it may be safely stated that this waste would not long continue without a vigorous protest from thousands of citizens. But let these cars of coal be wasted at the rate of five tons per minute in the dashing waters of a great river by reason of its lack of development, as is true at Muscle Shoals, and let this water power be located in a section of the country more or less remote from public view, and ten years are required to bring about the necessary action to stop the waste.

But it has been accomplished, and under the direction of Col. Hugh L. Cooper, builder of the great Keokuk dam and a man of international engineering reputation especially in hydro-electric development, the first of the two great power dams is about to be constructed at Muscle Shoals in the Tennessee River. Before considering the significance of this undertaking to the American electrochemical industries a consideration of the dams themselves may be of interest.

Outline of Complete Project

The full project calls for three dams. Number one is a small structure, 15 feet high and 300 feet long, provided solely for the purpose of improving the navigable channel.

The greater of the power dams is Dam Number Two, about 104 feet high and 4500 feet long, which together with its 850-foot power house will contain 1,200,000 cubic yards of concrete. When it is remembered that the great Roosevelt dam on the Salt River in Arizona, 260 feet high and 680 feet long, contains only 240,000 cubic yards of concrete, and the new Croton dam of the New York water supply, 1200 feet long, contains 855,000 cubic yards of concrete, something of the magnitude of this greatest of concrete dams will be appreciated. According to present plans approved by U. S. Army engineers, the ultimate installation at Dam Number Two will amount to 480,000 horsepower and the electrical units will be giants in size, developing 40,000 horsepower each.

Fifteen miles upstream from Dam Number Two is the site of Dam Number Three, which though but 40 feet high will be 6425 feet long, making it the longest dam in the world for its length will exceed that of the great Assouan dam in the Upper Nile by 25 ft.

The motto of the famous builder in his construction work on Dam Number Two consists of but one word—Economy. The government has already provided for the emergency plants for the manufacture of nitrate at Muscle Shoals which will be driven by steam power and therefore it is regarded as unnecessary to increase the cost of the hydro-electric development by reason of undue haste. The government investment therefore will be held down to the lowest possible figure.

With respect to the cost of the power when developed it may be stated that estimates approved by U. S. Army engineers have placed the cost between $7 and $9 per horsepower-year, or less than 1½ mills per kilowatt-hour. This is contrasted with the cost of power at Niagara Falls which ranges from $10.50 to $20 or more per horsepower-year, or from 1.6 mills to upward of 3 mills per kilowatt-hour. True, industries already established at Muscle Shoals may require as much as 260,000 horsepower of this supply but it seems entirely likely that with the completion of the Muscle Shoals project 400,000 horsepower will be made available for the use of other industries at a remarkably low rate.

Retaining America's Leadership

It is well known that America leads the world in electrochemical products. Others may dispute American claims for leadership in other branches of chemical science, but in the field of electrochemistry and electro-

metallurgy the United States is admittedly foremost. The war is bringing to the American public a knowledge of the value of electrochemistry and electrometallurgy in a terrible lesson that will not soon be forgotten. Ignorance and indifference to the value of these key industries to our national welfare and existence have been responsible for conditions which have driven many important American electrochemical enterprises to other countries. As long ago as 1907 the American Cyanamid Company, after strenuous endeavors to secure a location on one of our great Southern power streams, was compelled to withdraw from the country entirely and locate on the Canadian side of Niagara Falls. Since that time hardly a year has passed that some important industry has not sought its greatest essential—cheap power—in the bleak northern lands of Canada and Norway.

But it now seems evident that the enlightened public opinion in America will assure our electrochemical industries that the supremacy which they have gained in spite of these handicaps shall not be taken from them, and evidence is not wanting in Washington that there is a growing appreciation of the value of Southern water powers and Southern resources in the expansion of these great industries.

SITE OF DAM NUMBER TWO, MUSCLE SHOALS

If throughout the length and breadth of the country Nature has provided a happy combination of advantages for the electrochemist, it is in the Southern Appalachians and the adjacent territory. Here is an abundance of water power, closely associated with mineral and other natural resources which for variety have no equal within a similar area elsewhere in the United States. From the Potomac on the north to the Alabama on the south there is not a single important Southern stream that is without its power section, and developments have been many, particularly in southern North Carolina, northwestern South Carolina and northern Georgia.

But while the eastern slope of the Appalachians is drained by a score of streams, the western slope is drained almost entirely by the many small streams which unite to form the majestic Tennessee. So it happens that the greatest of the power streams of the Southern states is the Tennessee River, and the greatest undeveloped power on the Tennessee River is at Muscle Shoals in northern Alabama where reliable government records covering a period of 72 years assure a conservative basis for dependable hydro-electric development. The advantages of this location for the electrochemist become evident when we inquire into the needs of electrochemical processes for producing the essentials that we all now know are among our most important national requirements.

Essential Electrochemical Industries

First and foremost we need within our borders, and preferably within the safety area fixed by the War College, the necessary plants for the fixation of nitrogen to provide nitric acid and ammonium nitrate for explosives, dyestuffs and fertilizers. The only method of nitrogen fixation which has seen commercial success on this side of the Atlantic is known as the cyanamid method, and no stronger endorsement for Muscle Shoals can be brought forward than the fact that here the government is expending $30,000,000 in a vast establishment for the fixation of nitrogen by this process. Other processes are also under development by the government at this point but it is a source of gratification that while developing these untried processes the government is proceeding along adequate lines by employing a well-known method in order to secure its immediate requirements.

The growth of the electric steel industry in the United States has been most remarkable. With but 42 furnaces in operation and building in January, 1915, there were 233 by the end of 1917, and America has become the leader of the world in electric steel manufacture, outdistancing all competitors by a wide margin, for Great Britain comes second with 150 electric furnaces installed and in operation in 1917.

Of especial value is cheap power in Southern steel making. For many years the South has labored under a severe disadvantage because of the high phosphorus and high sulphur content of its ores, because in making steel by the Bessemer process these impurities could not be satisfactorily removed. But the advent of the electric furnace equipped with an abundant supply of cheap power promises to revolutionize steel making in the South, for this furnace used for refining the molten charge of the open-hearth furnace yields an electric steel which acknowledges no superior and finds an equal only in the high-priced crucible steel.

Muscle Shoals is surrounded by iron ores of great richness and the reserves are estimated in the hundreds of millions of tons. For many years the Muscle Shoals locality has had its blast furnaces, and during the past year it has shipped many tons of pig iron to Illinois by water at less cost and in less time than the shipment could have been handled by rail. In shipping this iron in pig form to the Northern manufacturer, this section has but followed the economic error of other parts of the South, for it must be admitted, though without credit to the South, that the shipment of raw material from this section to other localities has been the common practice. With the advent of cheap power, with an abundance of raw materials, and with the unexcelled supply of labor, the time seems not far distant when the South will do far more of its own manufacturing.

Among electrically reduced metals, aluminium is claiming a most important part in meeting war requirements of the past few years. Aluminium manufacturers have been compelled to ship their raw materials from Arkansas to St. Louis and thence to Niagara Falls, more than a thousand miles, for reduction. Bauxite is found in many places in the South, for while the largest production in the United States is found in Arkansas, there are important deposits in Georgia, Alabama and Tennessee, and the development of cheap power at Muscle Shoals should make possible the establishment of a great aluminium industry in this vicinity.

A rival of aluminium that promises to surpass it in usefulness for many purposes is magnesium, which can be alloyed to produce a material as light as aluminium and yet, according to Dr. Fink, as strong as soft steel. The country rock in the Tennessee valley is largely magnesian dolomite, and one of the interesting problems for the electrochemist is the recovery of this promising metal from this tremendous supply of raw material.

Proximity of Power and Raw Materials

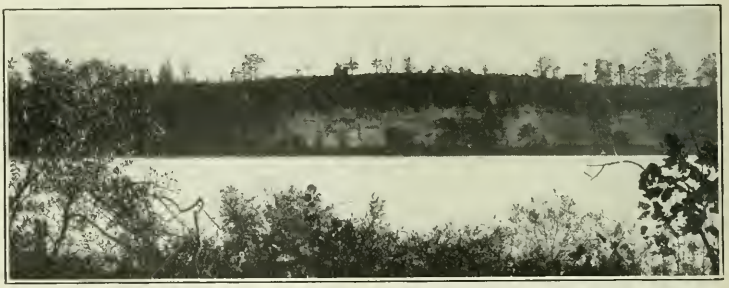
Equally fascinating is the recovery of potash from the high-grade potash feldspars which are abundant throughout the Southern Appalachians, and on good authority it may be stated that this problem has been reduced to one of the cost of power alone.

Valuable service has been rendered by the electric current in the refining of metallic zinc and the experience of the American Zinc Company at Mascot, Tennessee, is evidence of what is in store for the electrochemist when the South's resources are scientifically investigated. For many years the deposit of zinc at Mascot was regarded as comparatively unimportant but with the increasing demand and higher price of the metal the American Zinc Company undertook systematic drilling to investigate its properties and developed reserves of ore which justified the installation of a great modern concentrating plant. This is the type of investigation which is sorely needed in the South. We have had far too much guessing in dealing with our raw materials and the many disappointments which are charged against Southern developments may be fairly said to have been largely due to a lack of systematic investigation.

Those aristocrats of the metallurgical trade, the ferro-alloys, sometimes shipped by express in carload lots in these days of great demand, have already become established in the valley of the Tennessee. Both ferrosilicon and ferro-phosphorus are made in quantities within a comparatively short distance from Muscle Shoals although neither industry enjoys the advantages of $9 power.

High-calcium limestone and coking coal, so necessary for the manufacture of calcium carbide, are available in abundance, and cheap salt from the wells of West Virginia and from Louisiana provide the basis for chlorine, caustic alkali, sodium and a long line of other electrochemical products. The graphite fields of Alabama, hardly 150 miles from Muscle Shoals, afford a large and increasing supply of the raw material for electrodes, and the vast beds of phosphate rock hardly 60 miles from the Shoals, and which will soon be available by water transportation, offer to the master of electrochemistry a wonderful opportunity in the manufacture of phosphorus fertilizers and phosphorus metal.

In fact it is only necessary to refer to the map to observe the multitude of centers of commercial production of raw materials useful in electrochemistry and electrometallurgy which are found within the territory adjacent to the great power site at Muscle Shoals. Study of Southern resources has developed the fact that if a circle of 300 miles radius be drawn with Muscle Shoals as a center it will embrace a greater variety of commercially produced raw materials than is to be found in a similar area anywhere else in the United States.



LIMESTONE QUARRY SITE NEAR MUSCLE SHOALS

And when to an abundant supply of cheap power of great dependability and a large variety of raw materials there is added mild climate with its freedom from ice troubles in the power plants and where living is cheaper than in the more rigorous latitudes, and an abundant supply of suitable labor—for Muscle Shoals with its great government cantonments has already become an important labor center—and when it is remembered that here in great variety are factory sites having direct transportation by rail to nearby markets, north, south, east and west, and connection by water with the 14,000 miles of navigable streams which comprise the Mississippi River system, then it may be realized in a measure how commercially advantageous to the manufacturer is the location of Muscle Shoals.

Incombustible Celluloid in Japan.—According to Commerce Reports a noncombustible substitute for celluloid has been invented by a professor in a Japanese university, and a company has been organized for its manufacture. The factory buildings are now in course of construction, and it is planned to begin in April of this year, or soon after, the manufacture of waterproof cloth, and composition tiles, buttons and insulators. As soon as machinery ordered in the United States arrives, the manufacture of imitation leather, Linoleum, stained glass, marble, lacquers, and varnishes will be started. Patent rights have been obtained for linoleum, stained glass, marble, lacquers, and varnishes Japan and have been applied for in foreign countries.

Production of Electrometallurgical or Electrochemical Products Per Kilowatt-year*

VERY frequently the problem arises: A waterfall of x hp. is to be made available through transformation into hydro-electric power for the production of electrochemical or electrometallurgical products. What tonnage of products will it be possible to produce?

In a general way, on the shaft of the turbines only 80 per cent of the power of the waterfall is generated, calculated from its height and volume per second, this volume being carefully ascertained by an average annual figure resulting from numerous gaugings for rivers not provided with dam-reservoirs.

A new figure is next obtained by taking into account the losses suffered by the current before being utilized in the electric furnaces or in the electrolytic vat.

10% (on 80%) in dynamos, balance..... 72%
1% (on 72%) in the transmission line, balance 71.28%
3% (on 71.28%) in transformers 69.14%
1% (on 69.14%) in conductors 68.45%

Finally, supposing a waterfall of 5000 hp. is available, the current actually utilizable at the terminals of the furnaces or vat does not amount to more than $5000 \times 68.45 = 3422.50$ hp. Besides, in any electrochemical plant a number of accessory machines are used for the purposes of manufacture. For instance, in a calcium carbide, or ferro-silicon plant, there will be found crushers and grinding mills for both raw materials and finished products, conveyors, pumps, not mentioning even dynamos for lighting purposes, etc. All these apparatus are driven by electric motors which consume current amounting to one-tenth the power available at the plant. The figure of 3422 hp. is thus finally reduced to 3000 hp. and, of the 5000 hp. water power, only 60 per cent, or 2200 kw., is actually available for manufacturing purposes.

Supposing the current to be applied for the manufacture of electrochemical or electrometallurgical products, what can be obtained from one kilowatt during one year? To begin with, a statement must be made as to what is meant by the expression "kilowatt-year." It is not the power of one kilowatt utilized during 365 days of 24 working hours or 8760 kw.-hr. Actually, owing to accidents, inevitable interruptions for the inspection of the machinery, repairs, etc., even in plants intended for continuous operation, work is carried out during only 8000 hr. per year, and, thus, one kilowatt-year is equivalent to 8000 kw.-hr.

In the case of a plant which disposes of 2000-3000 kw. the following outputs may be obtained per kilowatt-year (meaning 8000 kw.-hr.):

Calcium carbide.....1600-1800 kg.

The output is reduced to 1000-1200 kg. in case small furnaces are used and is invariably above 1800 kg. in the large-sized furnaces consuming each 5000 to 6000 kw.

Ferro-silicon with 50% Si.....1000-1100 kg.

These figures are reduced to 1000 kg. with 1000-kilowatt furnaces operated with anthracite or coke. On the other hand, the figure is raised to 1200 kg. and even 1400 kg. with charcoal-operated furnaces.

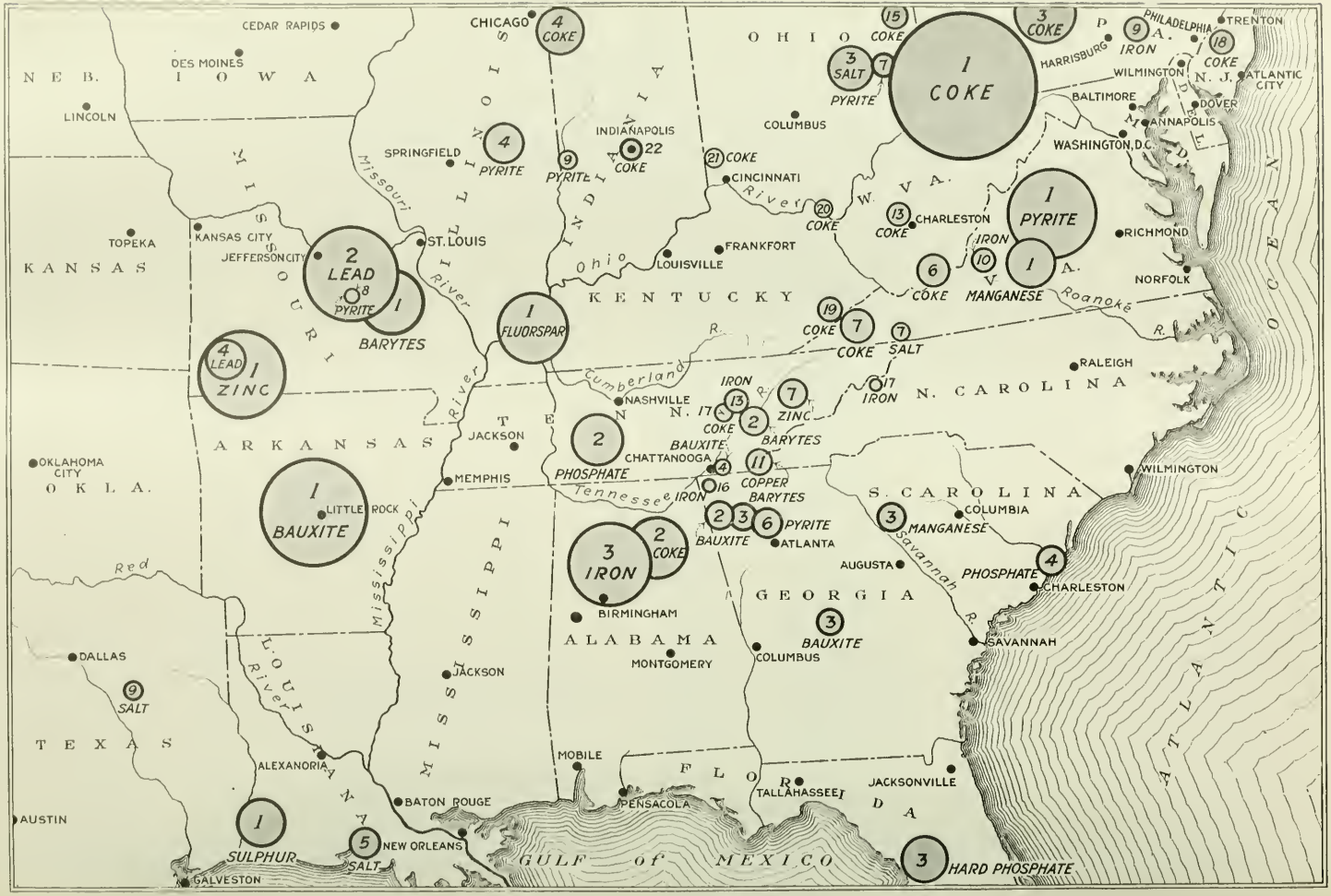
Ferro-silicon with 75% Si.....500-600 kg.
Ferro-silicon with 90% Si.....350-400 kg
Ferro-chromium with 8% C.....800-900 kg.

This output diminishes rapidly according as the carbon-content is lowered since this is effected by successively remelting the high-carbon alloy in presence of chromium-bearing ore.

Ferro-nickel with 50% Ni.....300 kg.
(By reduction of an ore carrying about 5% Ni)
Ferro-tungsten with 50% W.....1000 kg.
Ferro-molybdenum .....900 kg.
Ordinary aluminium with 98-99% Al.....250-270 kg.
Aluminium nitride with 20% N.....1500-1800 kg.
Carborundum (crystallized).....300 kg.
Carborundum (amorphous).....500-600 kg.
Calcium nitrate (synthetic).....350 kg.
Caustic soda (electrolytic).....6-8 tons (metric)
Potassium chlorate.....6-8 tons (metric)
Chlorine (electrolytic).....6-8 tons (metric)
Pig-iron (high grade).....3-4 tons (metric)
(Starting from rich 50-60% ore and according to the nature of the reducing agent, whether coke or charcoal.)
Pig-iron (synthetic).....10-12 tons (metric)
(Obtained from steel turnings.)
Pig-iron (synthetic).....8-10 tons (metric)
(Obtained from a mixture of crop-ends, turnings and ore.)
Tool-steels .....20 tons (metric)
(Obtained from a liquid charge.)
Steel, high-grade carbon.....10-12 tons (metric)
(Obtained from a cold charge.)
Steel, refined in the electric furnace, 35-45 tons (metric)
(Obtained from a basic steel poured directly from converter into the electric furnace. The figure of 40 tons is double in acid operation, or .....80 tons (metric)
Steel, ordinary grade for casting..12-15 tons (metric)
(Cold charge with turnings.)
Iron, pure, electrolytic.....2 tons (metric)
Zinc, by electrothermic reduction.....1200 kg.
(Obtained by reduction of the ore in the electric furnace.)
Zinc, electrolytic.....2 tons (metric)
(Obtained by electrolysis of a solution of zinc salts from ore analyzing 30% Zn and 15% Pb.)
Copper, electrolytic.....90-95 tons (metric)
(Obtained by electrolytically refining crude copper.)
Copper, electrothermic.....2-3 tons (metric)
(By treatment of ore carrying 25% Cu.)
Sodium, metallic.....550 kg.
Calcium, metallic.....140-150 kg.
Manganese, pure.....140-150 kg.
Ferro-manganese, electrothermic.....10 tons (metric)
Silico-manganese and silico-spiegel...10 tons (metric)
(Output varying considerably according to composition of alloys.)
Magnesium .....300 kg.

In conclusion, it will be restated that these figures are only relative being essentially a function of the skill put into the operations, of the size and type of the apparatus, and, frequently, of the nature of the current.

*Translated from Jour. du Four Electrique, 1918, March 15, vol. XXVII, pp. 49/50



RESOURCE MAP OF SOUTHERN STATES

Adapted from a Complete Map of the United States Prepared by the Nashville Section, Engineering Association of the South

Mineral Resources of the Appalachian South

A Symposium by Southern State Geologists on the Raw Materials Suitable for Chemical, Electrochemical or Metallurgical Development

A GLANCE over a map of the Southern States such as appears on the opposite page, on which has been indicated the location of important mineral-producing districts, will visualize clearly the importance of the Appalachian South in our present and future industrial life. Only the most important mineral products are here shown, but the full significance of the resources of this region can be gathered from the fact that of the 57 useful minerals produced in the United States every one is mined in the South except platinum and borax. Owing to the limitations of space the map does not show the pebble phosphate district of the Florida peninsula, which is first in importance in this country. The numerals in the shaded areas in the map indicate the relative importance in the United States of the regions producing the several mineral products. It will be seen at a glance that the area shown leads in the production of coke, pyrite, manganese, fluorspar, barytes, zinc, bauxite, sulphur and phosphate (not shown).

In an address on the industrial resources and opportunities of the South delivered by A. D. Little before the American Chemical Society at New Orleans, April 1, 1915, the speaker gave the following concise summary of the industrial position of the South:

"In general it may be said that the South to-day is in a far stronger position industrially than the entire country was in 1880. It cuts more lumber, mines nearly twice as much coal, produces nearly four times the petroleum, and nearly six times the spelter. It has more looms and spindles and a much larger investment in manufacturing plants. Its agricultural capital is greater and the products of its farms are worth fifty per cent more. It makes nearly twice as much pig iron and twice as much coke as the whole country produced only thirty-five years ago."

In another article in this issue by Richard K. Meade a comprehensive statement of the South's mineral resources is given and in the following paragraphs we present more detailed statements.

Mineral Resources of Alabama of Chemical and Metallurgical Importance

By Eugene A. Smith
State Geologist

These resources are here presented in the order of their relative commercial value.

Coal and Coke.—The Warrior field contributes about 84 per cent of the total production, mainly from the Brookwood, Pratt and Mary Lee groups, which produce most of the coking coal and more than half of all the coal mined in the state. The Cahaba field contributes something over 12 per cent of the state's total, and the Coosa field about 4 per cent. The total production of coal in Alabama in 1916 was valued at $24,859,831. The coke production was valued at $13,019,139, and the coke found local use in furnaces of the companies manufacturing it. Of the value above given $3,828,057 is credited to bee-hive ovens and $9,191,082 to by-product ovens. Of these the Tennessee Coal, Iron and Railroad Co. at Ensley operates 240 Semet-Solvay ovens, and at Fairfield 280 ovens of the Koppers type. The Woodward Co. operates 170 Koppers and 60 Wilputte ovens; the Central Iron & Coal Co. at Holt have 60 Semet-Solvay ovens active, and the Gulf States Steel Co. at Alabama City have in operation 37 Koppers ovens. These establishments, in addition to the coke, turn out tar, benzol, toluol, naphtha, ammonium sulphate and naphthalene, with a value about equal to that of the coal used.

Iron Ores and Pig Iron.—The iron ores in 1916 were valued at $10,843,231, and the pig iron produced from them was valued at $38,994,660, an instructive illustration of the great increase in value of even the first derived product over that of the raw material. Roughly speaking the red ore or hematite of the Clinton or Red Mountain formation constitutes something over 80 per cent of the total iron ore production of the State. The most important development of this ore is on East Red Mountain between Birmingham and Bessemer, but other important occurrences are around

Attalla and Gadsden, and localities to the northeastward. The soft red ore, as delivered to the furnaces, contains on an average, metallic iron 50.80, silica 18.50, alumina 3.65 and lime 1.20 per cent, while the hard or limey ore carries metallic iron 37.00, silica 13.44, lime 16.20, alumina 3.18, carbonic acid 12.24. When the lime content of the ore is equal to the sum of the silica and alumina the ore is self fluxing.

HIGH-GRADE POTTERY AND PAPER CLAY, BED 15 FEET THICK, LANGLEY, SOUTH CAROLINA

The brown ore, in 1916, represented about 18 per cent of the State's production. The usual mode of occurrence is in irregular concretionary masses in residual clays resulting from decay of Paleozoic limestone in the Appalachian valleys.

An average analysis of a good quality of brown ore as delivered to the furnaces in Alabama, is, as follows: Hygroscopic and combined water, 13.00; metallic iron, 48.54; silica, 11.22; alumina, 3.61 per cent.

Limestone, Clay, Lime and Cement.—The chemical and metallurgical uses of limestone are for Portland cement, for furnace flux and for lime-burning. The limestone for these purposes in 1916 represented a value around $2,000,000, the Portland cement industry claiming a good deal more than half of this value. At present only two Portland cement plants are active in Alabama, viz., the Standard Co. at Leeds and the Coosa Co. at Ragland, both utilizing the Trenton limestone and the Clinton and Mississippian shales occurring in close proximity. The Demopolis Co., utilizing limestone of the Selma chalk, and its residual clays, is at present inactive. A future possibility for this industry in the Coastal Plain region is in the St. Stephens limestone with nearby clays of Grand Gulf age.

The stone for furnace flux for many years was from the Trenton and Mississippian formations, but in the Birmingham District the dolomite of the Knox formation has been found to be superior to the limestone and is in general use. The average composition of the limestone is silica 3.50, oxides of iron and aluminum 1.00, carbonate of lime 94.6 per cent. The average composition of the dolomite is silica 1.25, oxides of iron and aluminum 1.00, carbonate of lime 54.0, carbonate of magnesium 43.00 per cent.

For lime-burning the stone of Trenton age is very generally used, the center of the lime-producing industry being in Shelby County, between Pelham and Calera. Other important plants are in Etowah and Jackson and Lee counties, the stone at the latter place is a crystalline dolomite of undetermined age. This lime, used for chemical, agricultural and building purposes represented in 1916 a value of nearly $300,000.

The chemical and metallurgical uses of clay are practically confined to the Portland cement manufacture and to the production of fire-brick used in the furnaces, statistical figures for which are not available.

Graphite.—The graphite field in Alabama extends from Chilton through Coosa and Clay counties into Randolph. The ore is a mica chist with average content around 3 per cent graphite. The most important developments at present are around Ashland in Clay county with, however, notable activity in Chilton and Coosa counties. The graphite industry has shown a remarkable development. Up to 1913 the production was less than 1,000,000 pounds from two or three companies. From 1913 to 1916 the number of active companies increased from two to seven, and the production from 2,020,000 to 5,226,940 pounds. In 1917 twenty-one companies were active, and in 1918 up to April 1, twenty-four companies were active producers, but we have not yet the figures of production. All the Alabama graphite is shipped into other states and used chiefly in the manufacture of crucibles and for foundry facings. Recent experiments have shown that the Alabama flake graphite can entirely replace the Ceylon mineral in the manufacture of crucibles.

STRIPPING BED OF SEDIMENTARY KAOLIN NEAR AIKEN, SOUTH CAROLINA

Pyrites.—At the present time known commercial deposits of pyrites are confined to a very limited area near Pyriton in Clay County where the ore, associated with an altered ignesous rock, occurs in lenses of varying size, averaging perhaps 10 to 14 feet in thickness of the ore, which in part is shiping ore, but in part needs concentration. A thin band in the orebody carries a small percentage of copper. For some years previous to 1917 there was no production of pyrites in Alabama, but in the year named three companies have been active, but the production is not yet available. Near Hightower in Clebourne County, a vein of copper-bearing pyrrhotite has been worked for copper, though nothing has been done here for many years.

Barytes.—Occurrences of barytes of commercial promise have been observed in Calhoun, Selby, St. Clair, Jefferson and Bibb Counties, usually in the red

residual clays from Trenton limestones and in the fissures in these rocks. The crude ore is shipped to outside markets, no barium products or barium chemicals being manufactured in the State. The production in 1916 by four operators was 7631 short tons, valued at $27,198.

OPEN CUT BARYTES MINE SHOWING SIX-FOOT VEIN OF ORE AFTER STRIPPING, KINGS CREEK, SOUTH CAROLINA

Bauxite.—The known commercial bauxite deposits of Alabama are in Cherokee, Calhoun and DeKalb Counties, where it occurs generally associated with kaolin in pockets, mostly near the base of quartzite ridges and bordering red-clay areas that have resulted from the weathering of Knox dolomite.

There being in 1916 and for several years before that, only one producer of bauxite in Alabama, the tonnage cannot be revealed. The raw mineral is shipped out of the State for the manufacture of metallic aluminium, aluminium salts, abrasives and refractories.

Mica.—Mica mines were opened in Alabama during the early days of mica mining in the Southern states. Considerable developments have been made at intervals during the last 20 years in most of the counties of our crystalline schist areas. In 1915 and 16 sheet mica of excellent quality has been produced valued at between five and six thousand dollars.

Mineral Resources of Georgia

By S. W. McCallie
State Geologist

The mineral resources of Georgia are both varied and extensive. The state is producing at present 34 different kinds of minerals in commercial quantities. This great diversity of mineral resources is accounted for in a large measure by the great diversity in the geological formations.

Asbestos.—The asbestos deposits of Georgia are chiefly to the Piedmont Plateau, where they are found associated with dark-colored, igneous rocks. There are two varieties of asbestos, the chrysotile and the amphibole.

The latter variety is extensively mined in Habersham and White Counties, near Nacoochee, this state. The White County mines here referred to have been the chief producers of asbestos in this country for several years.

Barytes.—The Georgia barytes deposits, which have so far been worked in a commercial way, are located near Emerson, Bartow County, and at Eton, Murray County. The mineral is largely used as a substitute for white lead. It is used also in the manufacture of paper, rubber, oilcloths, paper collars and barium salts, as well as for refining sugar, glazing pottery and for enameling iron. Georgia last year produced about two-thirds of the barytes mined in the United States, all of which came from the Cartersville district.

Bauxite.—The first bauxite found in America was discovered near Hermitage, Floyd County, in 1887. Later, deposits were found in Polk, Bartow, Gordon, Chattooga and Walker Counties, and between 1907 and 1915 deposits were found in the vicinity of McIntyre, Wilkinson County, near Andersonville, Sumter County and also near Warm Springs, Meriwether County. Since 1888 a high percentage of the bauxite mined in this country has been obtained from Arkansas, Georgia and Alabama.

Chromite.—Only two counties in Georgia, namely, Towns and Troup, as far as known at present, have chromite in apparently commercial quantity. The deposit in Town County is located two miles due west of Hiawassee, on lot 92; while the deposit in Troup County is near Louise. From the latter locality a limited amount of ore has recently been shipped. The ore in both localities is associated with ferro-magnesian rock and is generally found in the form of boulders in residual clays.

Fullers Earth.—The best known deposits of fullers earth occur near Dry Branch, Twiggs County, and in the vicinity of Attapulgus, Decatur County, where they have been worked for some years. Extensive deposits also occur in Bibb, Columbia and other counties near the Fall Line. The deposits of Twiggs County are now being worked by the General Reduction Company. Georgia stands second in the production of fullers earth, being exceeded only by Florida.

HIGH-GRADE PAPER CLAY, MENAMEE KAOLIN COMPANY, BATH, AIKEN COUNTY, SOUTH CAROLINA

Graphite.—Both amorphous and crystalline varieties of this mineral occur in Georgia. The amorphous variety is quite abundant in the neighborhood of Emerson, Bartow County, where it has been mined on a more or less extensive scale. Fine samples of crystalline graphite have been found in Bartow, Pickens, Elbert, Hall, Madison, Douglas, Troup and

DRYING SHEDS, GEORGIA SEDIMENTARY KAOLIN MINE. HEPHZIBAH, RICHMOND COUNTY, GEORGIA

Cobb Counties. All of the graphite material so far mined in Georgia has been used as a filler for commercial fertilizers.

Iron Ores.—Iron ores occur in Georgia in large quantities. The most common ores are the brown ores, or limonites, and the fossil ores, or hematites. Magnetite also occurs. The brown iron ores are most abundant in Polk, Bartow and Floyd Counties, but workable deposits are also to be found in nearly every county in the northwestern part of the state. The ores associated with the Weisner quartzite sometimes occur in ill-defined veins, but more generally they are found in the form of pockets or irregular deposits in the residual clays. The brown iron ores of the Knox dolomite series occur chiefly in the form of pockets or irregular deposits in the residual clays. The deposits are quite variable in size. Some of the individual deposits in the vicinity of Cedartown have been worked on an extensive scale for more than ten years without exhausting the supply.

The red, or fossil, iron ores of Georgia are confined to Dade, Walker, Chattooga and Cataoosa Counties. These ores occur in the Red Mountain iron ore-bearing series, which is so well developed near Birmingham. These ores occur in contiuous beds varying from a few inches to several feet in thickness. Some idea may be had as to the abundance of the red fossil iron ores of Georgia when it is stated that the aggregate length of the outcroppings of the beds, which average more than two feet in thickness, is approximately 175 miles, and that in many places the ore can be economically mined to the depth of several hundred feet.

Manganese.—The manganese ores, like the brown iron ores, are confined chiefly to Bartow, Floyd and Polk Counties. The largest and most productive deposits are found in the vicinity of Cartersville, where the ores occur as irregular deposits in the residual clays derived from the Beaver limestone and the Weisner quartzite. The manganese deposits of Georgia have been worked almost continuously for many years. During their early workings the ores were shipped to England, but in the last few years they have found a ready market in this country, where they have been used in the manufacture of steel and for bleaching powder.

Mica.—Mica is widely distributed throughout the Piedmont Plateau. It has been worked to a limited extent in Upson, Cherokee, Lumpkin, Union, Hall and Rabun counties. Some of the most promising prospectsin Cherokee County are in the vicinity of Holly Springs and Toonigh, and in the Hickory Flats district about ten miles southeast of Canton. The Lumkin and Union County deposits, as so far developed, occur near the Lumpkin-Union county line. Upson County is now an active producer as well as Meriweather County. Mica has been mined in Rabun County at the Kell Mica Mine, 10 miles east of Clayton, and in Hall County, near Gainesville. In addition to these localities, good mica prospects are found in a large number of other counties in the Piedmont Plateau.

Ocher.—The ocher mines of Georgia produce more than one-half the yellow ocher output of the United States. These mines are located near Cartersville, Bartow County. The deposits are confined to a narrow belt about eight miles in length and less than two miles in width. The most extensive workings are those of the Georgia-Peruvian Ocher Company, situated on the left bank of the Etowah River, two and one-fourth miles east of Cartersville. Ocher mining in the Cartersville district had its beginning in 1887. In 1890, the Georgia-Peruvian Ocher Company began operations on an extensive scale, and later, three other large ocher plants were put in operation.

The total maximum output of these four plants is estimated at about 1,000 tons per annum.

The principal use made of the yellow ocher mined in Bartow County, up to the present time, is in the manufacture of lineoleums and oilcloths. The important markets are England and Scotland. It is also used to a limited extent in the manufacture of paints.

Potash-Bearing Slates.—Slates containing 7 to 10 per cent potash occur north of Cartersville, Bartow County, in a belt 15 miles long and 1 to 4 miles wide. The best exposures are near White, on the L. & N. Railway, where a thickness of several hundred feet of such material may be worked by open-cut methods. It is believed that these slates are exceptionally fine raw material for the extraction of potash for fertilizer and other purposes.

Pyrite.—This mineral occurs in commercial quantities in a number of counties. The most important deposits are in Lumpkin, Cherokee, Paulding, Cobb, Douglas, Harlson, Carrol, Towns, and Rabun counties. Mines operating in 1917 were the Chestatee mine, six miles northeast of Dahlonega, Lumpkin County; the

SOAPSTONE MILL AND STOCKYARD, OLD DOMINION CORPORATION, ALBEMARLE COUNTY, VIRGINIA

Standard mine near Creighton, Cherokee County; the Little Bob and Shirley mines near Hiram, Paulding County; the Marietta mine near Marietta, Cobb County; the Sulphur Mining & Railroad Company mine in Douglas County, and the Waldrop mine near Draketown, Haralson County. Other promising deposits, which have been worked in the past or rather extensively explored are Reeds Mountain, near Bremen, Haralson County; the Southern Star mine, four miles west of Woodstock, Cherokee County; the Swift mine near Draketown, Haralson County; the Swift or Blake mine at Creighton, Cherokee County; the Canton Copper mine, Cherokee County; and the Mammoth mine near Hiram, Paulding County. The copper ore from Mine No. 20, Fannin County, is also a source of sulphuric acid.

Sericite.—Sericite of exceptional purity occurs in Pickens County only a short distance west of Jasper, where it is found in beds from a few inches to six feet or more in thickness, interlaminated with quartz schist.

The mineral is a variety of mica made up of small elongated silver-colored shreds. It resembles talc very closely, in physical properties, and is often used for the same purposes.

The Pickens County sericite has recently attracted considerable attention as a raw material for the extraction of potash. Two different companies are now mining this material with a view of extracting the potash for fertilifier purposes.

Mineral Resources of Maryland

By Edward B. Mathews
State Geologist

Maryland is rather a center of supplies and refinement of mineral resources than a source of the raw materials. It was, however, the early finding of chromite, magnetite, copper, and iron in this region which led to the establishment of many of the larger industrial plants of Baltimore and vicinity. The presence of extensive deposits of serpentine carrying more or less chromite, the abundant distribution of pegmatite dikes with potash and soda spar, and the presence of extensive clay deposits including lenses of kaolin serve as the bases of industries in each of these mineral resources, and stimulate more or less prospecting for new or richer deposits. The large industries of coal, brick and tile, and cement are too well known to need further comment.

BLOCKS OF SOAPSTONE AS TAKEN FROM QUARRY—OLD DOMINION SOAPSTONE CORPORATION, ALBEMARLE COUNTY, VIRGINIA

MINING MANGANESE ORE WITH STEAM SHOVEL, NEAR FRONT ROYAL, VIRGINIA

Chromite has been the subject of renewed investigation and from prospects at one or two points small shipments may be expected. The bodies, however, are small and the tenor in available chrome generally 40 per cent or better. The material is found in place and also collected along stream bottoms.

Feldspar deposits have been prospected and there are a number of operations especially in the Patapsco Valley in the neighborhood of Marriottsville and Woodstock and in Cecil County in the vicinity of Rock Springs. The material of the first area is potash spar, that of the second rich in soda. The smaller operations are feeling the lack of labor supply more perhaps than larger industries.

Clay has been one of the chief mineral products of Maryland since pre-Revolutionary time and the products have covered quite a range. At present, however, the industry is largely limited to the production of brick and tile and refractories with some enameled ware. Attempts at the present time are being made to develop blends consisting of Maryland and Tennessee clays to meet the shortage of German and English supplies.

North Carolina Minerals

By Joseph Hyde Pratt
State Geologist

Within the borders of North Carolina is found a wide variety of minerals, and, with the exception of perhaps one or two other states, a greater variety than in any other state in the Union. While most of these are of little or no economic importance, several of them are of large commercial value, and, of a few, North Carolina is the chief producing State. The principal mineral resources of the State, however, are building stones and clay products. Of the several minerals the following represent those of commercial importance that are now being produced in the state.

Metallic Minerals

Iron.—The principal iron ores of North Carolina are magnetite, hematite and limonite, the most valuable being the magnetites in Mitchell and Ashe counties, carrying from 31.16 to 68.34 per cent metallic iron.

These are exceptionally pure ores and make a very high grade of pig iron. The producing mines of limonite at the present time are in Madison and Cherokee counties. This ore is produced largely by open cuts. The most promising deposit of hematite is at Bessemer City, Gaston County, and ore was formerly mined and shipped to Birmingham, Alabama.

Copper.—The copper ores are composed pricipally of the sulphides and in the Blue Wing district of Person and Granville counties the ores are mostly chalcocite and bornite. In the Gold Hill district of Rowan, Stanly and Cabarrus counties, the ore is principally chalcopyrite. This is also true of the Cullowhee belt in Jackson county. In the Ashe County copper belt, which contains one of the most extensively developed mines in the State, the ore is composed of a mixture of chalcopyrite, pyrrhotite and some pyrite. Another belt in Swain and Graham counties is known as the Hazel Creek copper belt. At these two latter localities, considerable native copper has been found.

The mines of the Gold Hill district are auriferous pyrite and chalcopyrite with which is more or less gold-bearing quartz. The latter is the only gangue mineral of any importance. In the Cid mining district of Davidson County, the ores at the Silver Hill mine consist of a complex mixture of galena and sphalerite together with pyrite and chalcopyrite, the whole carrying silver and gold. At the Conrad Hill mine, the ores all consist of auriferous pyrite and chalcopyrite in a gangue of quartz, siderite, and hematite; and at the Emmons mine, the ores are auriferous pyrite and chalcopyrite in a quartzose gangue or as narrow stringers in the schists with little or no gangue.

Gold and Silver Ores.—The gold ores consist of free-milling and sulphide ores. The larger deposits of free-milling ore occur in what are known as slates and some of the difficulties encountered have been the separation of the very finely divided gold from the slates, which have some tendency to slime. In some of the mines the gold is rather coarse and little difficulty is experienced in saving it on plates. The lower portion of these deposits runs into the sulphides.,,The principal gold region of the State is that known as the "Carolina Gold Belt," extending across the central Piedmont region of the State running from the Virginia line in a southwesterly direction across Person, Orange, Guilford, Randolph, Davidson, Davie, Rowan, Montgomery, Stanly, Moore, Cabarrus, Mecklenburg, Catawba, Lincoln, Gaston, Cleveland, Union, Caldwell, Burke, McDowell, Rutherford, and Polk counties.

There is very little silver associated with the gold and the gold bullion is in a high state of fineness, running to 997. There is more or less silver associated with the copper ores of the State. There are but two silver mines known at the present time in North Carolina, the Silver Valley and the Silver Hill mines in Davidson County. The original ore in these mines is a mixed sulphide and in the upper portions of the vein where the sulphides have been decomposed, mining was carried on very extensively. When, however, the unaltered sulphides were reached, they were found to be composed of pyrite, chalcopyrite, galena and sphalerite, and on account of the complex character of the ore, it could not be profitably treated, and therefore mining operations were suspended. It is believed that now these complex ores can be separated and the ore bodies worked profitably.

Tin.—The most promising tin deposit in the eastern United States is near Lincolnton, Lincoln County, North Carolina. Casseritite, tin oxide, occurs in a decomposed pegmatite dike and, by working the deposit as a source of kaolin and saving the tin as a by-product, it is believed this property could be worked profitably. The tin ore occurs usually near the contact of the dike with the country rock and forms approximately ½ of one per cent of the contents of a width of 4 to 5 feet in the dike.

Chromite.—The principal chromite deposits are in Yancey County, and these are now close to railroad transportation. These deposits contain some of the highest grade chromite known, the Ray mine carrying ore running as high as 58 per cent chromic oxide per ton. Other promising deposits occur near Webster, Jackson County. These deposits are the most promising sources of supply of this mineral in eastern United States.

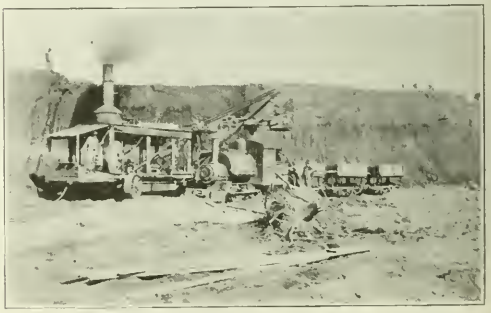
Manganese.—More or less manganese is found associated with many of the limonite iron ores. The most promising deposit is in Surry County where a property has recently been opened, but no quantity of ore has thus far been mined. An analysis of this ore gave 42.87 per cent of metallic manganese.

Non-Metallic Minerals

Corundum.—North Carolina was formerly the chief corundum-producing State in this country, but for several years very little of this mineral has been mined. The corundum deposits in Clay and Macon counties represent probably some of the largest deposits of crundum in this country. The corundum is of splendid quality.

Mica.—North Carolina mica has been known for years as "standard mica" and is considered the best grade of mica on the market. Many of the western counties contain mica in commercial quantity and its production has been constantly increasing for several years. It occurs in pegmatite dikes and is produced in the following counties: Mitchell, Macon, Jackson, Yancey, Haywood, Transylvania, Avery, Watauga, Ashe, Cleveland, Buncombe, McDowell and Stokes.

Monazite is found very extensively in the gravels of Cleveland, Rutherford, Burke, Polk, Lincoln, Catawba,



MINING BROWN IRON ORE WITH STEAM SHOVEL, RUSSELLVILLE, ALABAMA

McDowell, Gaston and Alexander counties. All the production is from placer mines. The gravels are washed and the concentrates cleaned magnetically so that the final monazite product contains approximately 95 per cent monazite. The most notable occurence of monazite in this country is near Mars Hill, Madison County, North Carolina, where in a pegmatite dike masses of nearly pure monazite were found weighing as much as 60 pounds.

Zircon has been found in commercial quantity in Henderson County in one of the pegmatite dikes. The commercial demand is small, and for a good many years one property has been able to furnish the entire known demand for this mineral in this country, its use being in producing zirconia for use in the manufacture of the glower for the Nernst electric lamp. It also occurs in some quantity near New Sterling, Iredell County.

Barytes is being mined in Madison and Gaston counties. It is a hard, compact variety of very high grade. It is usually granular in structure, but occasionally masses of some size are obtained made up of cleavable blocks.

Talc.—There are several localities in North Carolina in which talc occurs in commercial quantity. The most noted locality is the Hewitt mine in Swain County, which furnishes an exceptionally high grade of talc such as has not been produced at any other mine in this country. A splendid grade of talc also occurs in Cherokee County, and the soapstone variety occurs in Madison and Ashe counties. Pyrophyllite is mined in some quantity in Moore County and is used for some of the same purposes as talc. It has very similar physical but different chemical properties, it being a hydrous aluminum silicate.

Feldspar.—The potash variety of feldspar is now being mined in some quantity in Mitchell, Yancey and Watauga counties. The feldspar occurs in pegmatite dikes, usually in such form that it can be readily separated from the associated minerals. It is ground before being shipped.

Rare Minerals.—Several uranium minerals, such as uraninite, gummite, uranatil, and uranaphane are found in small quantity associated with some of the pegmatitic dikes of Yancey and Mitchell counties. The uraninite from the Flat Rock mine has the highest radio-activity of any uranium ore tested, according to Dr. B. B. Boltwood of Yale University. Several of the rare earth minerals have been found in some quantity in these pegmatitic dikes, such as samarskite, columbite, fergusonite, monazite, euxenite, hatchettolite, yadolinite, allanite and polycrose.

SOAPSTONE QUARRY SHOWING CHANNELING MACHINES —PHOENIX, NELSON COUNTY, VIRGINIA

Electrochemical Industries in Tennessee

By L. C. Glenn

Acting State Geologist

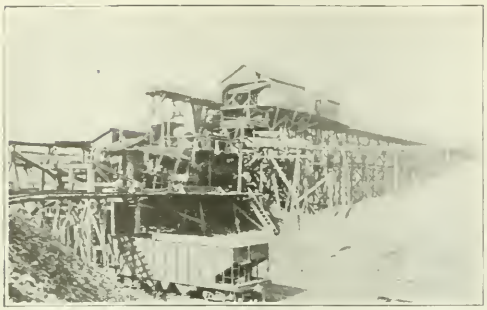
The electrochemical industry in Tennessee is in its infancy, just at present, but conditions for obtaining cheap electric power and abundant and varied supplies of raw materials are such that there are great possibilities for the development of these industries. It is the object of the present article to make a brief statement concerning present operations and indicate some of the most promising future possibilities.

Chlorine.—At Kingsport there has been noteworthy development of chemical industries of very varied type, and this is probably but a beginning of what the next few years will see at that place. Among these there is an electrolytic chlorine plant, and in connection with the Portland cement plant, potash is recovered as a by-product by the Cottrell process.

Aluminium.—At Maryville, near Knoxville, the aluminium plant consumes more electrical energy than any other one plant in the state. The raw materials for this plant come from Georgia, but deposits of bauxite are known at a number of places in Tennessee from near Chattanooga northeastward nearly to the Virginia line. There are developments of these deposits near Chattanooga and Elizabethton. The Maryville plant is planning for large hydroelectric development on the Little Tennessee River, and all indications are for a very great enlargement of their electrochemical work since when fully developed their series of dams will furnish about 400,000 horsepower.

Ferroalloys.—At Chattanooga a start has been made in the production of ferroalloys that gives much promise for future expansion. Aside from silica, which may be had in unlimited quantities for making ferrosilicon, there are pockety manganese deposits of high grade available in East Tennessee and the adjacent portion of Georgia for ferromanganese alloys, and in middle Tennessee there are large deposits of high-grade phosphate rock that would supply unlimited material for making phosphorus and ferrophosphorus. These latter substances are not as yet produced here electrochemically though a furnace in the phosphate field produces ferrophosphorus with coke as a fuel.

Undeveloped Possibilities.—Attractive possibilities for electrochemical experiment and development are furnished by the zinc ores of East Tennessee. These are now concentrated and shipped out of the state for reduction. With cheap power available and an abundance of ores, experiments in electrical smelting could be undertaken here under the most favorable circumstances. The manufacture of calcium carbide could be undertaken anywhere and abrasives could be made with equal ease. The iron ores of the region and industries dependent on iron and steel make it possible for both pig iron and steel to be produced by the electric furnace, and the demand for



BROWN IRON ORE WASHING PLANT, RUSSELLVILLE ALABAMA

such products must bring developments along these lines in the near future. Practically all of the raw materials now used in important electrochemical work are available either in the region or are accessible, as in the case of salt, in nearby regions.

Power and Labor Conditions, Etc.—Extensive development of hydroelectric power has already occurred in this region and there exist numerous other sites where large units may be developed at reasonable cost. Aside from such cheap hydroelectric power it is practicable to develop electric power very cheaply by steam in large plants located at any of the many coal mines in the Cumberland Mountain region of the state. Such plants would use slack coal delivered directly from the mine without railway haul, and could compete with hydroelectric power. The climate is favorable to continuous operation, and labor, under normal conditions, is abundant and cheap. Raw material of many other kinds is abundant and forms the basis for a varied industrial development in this region that must come in the near future.

Mineral Resources of Virginia in the Chemical Industries

By Thomas L. Watson

State Geologist and Professor of Geology, University of Virginia

Virginia produces annually more than thirty different mineral substances, the total value of which for the year 1916, the latest year for which completed statistics are available, including coke and pig iron, amounted to $30,407,414, proportioned as follows: Metallics, $2,088,492, nonmetallics, $18,154,007. The total value of coke and pig iron made in Virginia in 1916 was $10,164,915.

Among the metallics, the production includes ores of copper, gold and silver, lead and zinc, iron and manganese, and titanium; among the nonmetallics, asbestos, barite, cement, clay products, coal and its by-product coke, feldspar, gypsum, stone (granite, limestone, sandstone, and slate), lime, marl (greensand and calcareous), mica, millstones, mineral waters, pyrite and pyrrhotite, quartz, salt, sand and gravel, talc and soapstone, etc.

Some of these have been worked since early colonial days, especially coal, iron ores, and brick clays, while others are of more recent development, and all are capable of further greater expansion and production. Still others of scarcely less importance await development. Only a few of the more important raw mineral materials found in Virginia in commercial quantity and of value in the chemical and metallurgical industries can be mentioned in the space allotted.

Fuels.—The mineral fuel resources of Virginia are coal and its by-product coke, oil and gas not yet having been found in commercial quantity. The principal coal-producing territory of the State is in southwest Virginia and comprises approximately 1,550 square miles, including the whole or a part of Tazewell, Buchanan, Dickenson, Wise, Lee, Russell, and Scott counties. The coals are high grade bituminous and semi-bituminous varieties of established reputation for steaming and domestic purposes and for the manufacture of a superior grade of coke for various uses. Coals of excellent quality occur and are mined in other counties of western Virginia especially Montgomery and Pulaski.

An important coal area known as the Richmond coal basin, located in the eastern margin of the Piedmont province and covering parts of several counties, is the only area of free-burning coal in the eastern portion of the United States located immediately adjacent to Tidewater. The coals of this area were the first to be mined in the United States and they represent a good grade of the bituminous variety.

Limestone.—Inexhaustible supplies of calcareous materials admirably adapted to the various uses made of such materials, are readily available and extensively quarried over many parts of the State. These include the hard rock limestone and travertine (fresh water marl) of western Virginia, especially the Great Valley province, and more restricted areas of the former in the Piedmont province; and shell or calcareous marls of the Coastal Plain or Tidewater region. The limestones of the Great Valley region range in composition from calcium-magnesium carbonate to straight calcium carbonate, and are extensively quarried and utilized for all purposes made of limestone. Already many of the more important chemical industries of the State are partly based on the readily available inexhaustible supplies of this very necessary raw material.

Iron Ores.—The commercial deposits of iron ores in Virginia are confined to the Piedmont and Appalachian regions, and include the important types limonite or brown hematite, red hematite (specular

HIGH-GRADE FULLERS EARTH 20 FEET THICK, NEAR MACON, GEORGIA

and fossil), and magnetite. Of these, brown hematite is the most extensively mined and forms the principal source of the metal. The sulphides (pyrite and pyrrhotite) are mined on a large scale for acid making, and the iron residue ("blue billy") is utilized by the blast furnaces for making pig iron. Iron carbonates are found in several localities but thus far they have not proved to be an important source of the metal.

The brown iron ores of the Appalachian region, which include the "mountain," valley or limestone, and Oriskany ores, are commercially the most important ones in Virginia. The specular hematites of the Blue Ridge province are second in importance, the Clinton fossil ores third, and the remaining types are of minor importance.

The "mountain" brown ores extend along the west slope of the Blue Ridge, including the east side of the

BED OF PURE FINELY DIVIDED SILICA 50 FEET THICK, NEAR SHEFFIELD, ALABAMA

New River-Cripple Creek district. They range in iron content from 35 to 50 per cent, and in silica content from 10 to 30 per cent, with usually high manganese and phosphorus. The valley or limestone brown ores are distributed at intervals throughout the Valley province in association with the limestone residual clays. They are usually richer than the "mountain" ores, ranging in iron content from 40 to 55 per cent and in silica content from 5 to 20 per cent, with usually less than 1 per cent of manganese and enough phosphorus to be classed as a non-Bessemer ore. The Oriskany brown ores are the most important of the iron ores mined in Virginia. The principal producing district includes the counties of Alleghany, Botecourt, and Craig. They range between 35 and 50 per cent metallic iron, and are usually high in silica and manganese, resembling in this particular the "mountain" ores. The total number of blast furnaces in operation in the State is 14, several of which are making ferromanganese.

Manganese Ores.—Virginia has always ranked as one of the important manganese-producing states in the Union. The deposits extend over a wide territory in the Piedmont and Appalachian regions and include a large number of producing localities. Stimulated by the present war conditions the production of both high-grade manganese ores and manganiferous iron ores in the State has been recently greatly increased, and the deposits are capable of further greater production. New areas have contributed to the increased production. The ores are used both in the steel and chemical trade.

Acid-making Materials.—These include vast supplies of pyrite and pyrrhotite, which for many years have given Virginia the position of first producer of pyrite among the pyrite-producing states in the United States. The most important pyrite deposits are found in the Piedmont Plateau province, and have been and are still extensively worked in Louisa and Prince William counties, and to a less degree in several other counties, especially Stafford and Buckingham. The pyrite mines in Louisa and Prince William counties are probably the largest and most extensively developed ones in the United States.

The principal occurrence of pyrrhotite in the State is the "Great Gossan Lead" of Carroll, Floyd, and Grayson counties, which forms a well-defined vein of pyrrhotite up to 100 feet in width and traced continuously on the strike for a distance of more than 20 miles. It was formerly worked on the north end at Betty Baker, and has been mined on a large scale for the past fifteen years near Monarat, in Carroll County, by the General Chemical Company and treated in their plant at Pulaski for acid-making.

Besides pyrite and pyrrhotite, other sulphide ores mined in Virginia for purposes other than their sulphur, include the zinc blende deposits of the Valley region, especially those of Wythe County, the mixed sulphides, chiefly galena and sphalerite, of Albemarle, Louisa, and Spottsylvania counties in the Piedmont province, and the copper sulphides, chalcocite and bornite, of the Virgilina district, including Halifax and Charlotte counties, Virginia, and Person and Granville counties, North Carolina.

Salt and Gypsum.—Economically important deposits of salt and gypsum occur in southwest Virginia in the valley of the North Fork of Holston River in Washington and Smyth counties. These deposits have been extensively developed by two gypsum plants, one at Plasterco, the other at North Holston, and one alkali works of the Mathieson Alkali Company at Saltville, Smyth County, which is the center of the industry. The making of salt was stopped in 1903 and from that date to the present the salt brines have been utilized exclusively for the manufacture of alkali, chiefly sodium carbonate and caustic soda.

Barite.—This mineral has been mined for many years in various parts of the State. It occurs in many counties in the Piedmont and Appalachian regions, but the industry has been confined to only a few of them. The mineral is of excellent grade and entirely adapted to the various uses made of barite, especially in the manufacture of barium products. Many of the deposits capable of greatly increasing the present production remain practically undeveloped. The present principal mining operation is the old Hewitt mine located near Evington in Campbell County.

Rutile.—The largest and most important commercial deposits of rutile in the United States occur in the Roseland district, Nelson County, from which the entire production of the mineral in this country is derived from the mines of the American Rutile Company. Other deposits of this mineral of probable economic value are found in Goochland and Hanover

counties. The principal uses of titanium include metallic alloys, such as ferrotitanium and cuprotitanium, incandescent media for lighting purposes, mordants and dyes for leather and textiles, refractory coloring material for use in ceramics and the manufacture of artificial teeth, etc.

Miscellaneous Materials.—Under this heading are listed certain mineral materials which occur in Virginia that are no less important than those described above, but because of lack of space they cannot be discussed at present. Most of these have either produced or are producing, while others capable of producing have not been developed. These include tin (cassiterite), abrasives (emery, millstones, quartz, chert, and diatomaceous earth), mica, feldspar, asbestos, mineral paints, arsenic (arsenopyrite or mispickel), graphite, zircon, etc.

In conclusion it may be stated that Virginia's enormous supplies of high grade coal, limestones, and ores of various kinds, coupled with her abundant water resources, favorable and healthful climate, and excellent railroad facilities, afford almost unparalleled opportunity for the production and manufacture of a great variety of chemical and metallurgical products.

The Mineral Resources of West Virginia Available for Chemical, Metallurgical, and Electro-Metallurgical Manufacturing

By I. C. White
State Geologist

West Virginia possesses none of the precious metals in commercial quantity. However, dame Nature has endowed this State with such an infinite wealth of the common and more useful substances that her mineral wealth probably exceeds in value any equal area in any other political division of the continent. In fuel wealth of coal, petroleum, and natural gas she stands without a rival. With a greater variety of coal than Pennsylvania, she comes next to her in production, and within less than a decade bids fair to surpass even Pennsylvania in the output of bituminous coal. Her petroleum is of the highest grade produced anywhere in the world and although the industry began nearly 60 years ago her oil and gas wells still yield 8 to 9 million barrels of white-sand oil annually along with over 300 billion cubic feet of natural gas, practically two-fifths of all the latter product that is marketed in the entire United States, while the casing-head gasoline, and carbon black production (this last industry having originated in West Virginia) are of very great extent.

In the variety of bituminous coals, West Virginia stands unique—Steam, Domestic, Gas, Coking, High Volatile, Low Volatile or Smokeless, Splint, "Block," Cannel, oil shales being available in the several districts of the Commonwealth.

Location of the Several Varieties of Coal

The celebrated Pittsburgh coal bed, probably the most valuable single fuel deposit in the world, ideal for steam and general fuel, unexcelled for gas and coke (being the same bed as the one which furnishes the Connellsville coke for Pittsburgh's great iron and steel industries), underlies approximately 1,300,000 acres, largely in the northern half of the state. Under the principal portion of this vast area, this coal would average a recoverable thickness of six feet, or say 10,000 net tons to the acre, thus totaling 10 billion tons of commercial coal for this one seam.

This Pittsburgh coal is very rich in by-products as may be judged from the following average composition of the coal at 51 mines in the counties of Monongalia, Marion, Harrison, Taylor, and Barbour Counties, as determined by Mr. Frank Haas, Consulting Engineer and Chemist for the Consolidation Coal Company:

	Per Cent.
Moisture	1.43
Volatile matter	37.47
Fixed carbon	53.83
Ash	7.27
Total	100.00
Sulphur	2.59
B.t.u., per pound	14,014

A ton of Pittsburgh coal from the mines now owned by the Jamison Coal and Coke Company at Underwood, Marion County, West Virginia, and tested by the New England Gas and Coke Company, of Boston, Mass., gave the following by-products:

Ammonia	22 pounds
Coal tar	10 gallons
Surplus by-product gas	6,000 cubic feet
Coke	1,600 pounds

In addition to this great Pittsburgh seam in the northern half of West Virginia are two other principal coal beds; viz, the Upper Freeport Coal, 600 feet below the Pittsburgh bed, and the Lower Kittanning, the latter coming 175 to 200 feet lower. In the northern Panhandle, or Ohio, Brooke, and Hancock Counties, as also northern Wetzel, there is also a large area underlain by the Lower Freeport Coal, 50 feet below the Upper Freeport bed. This bed is 4 to 6 feet in thickness, and makes an excellent coke either in beehive or by-product ovens. It will form a great reserve of coal for the Wheeling and Ohio Valley manufacturing industries for many miles southward long after the great Pittsburgh seam lying 600 feet higher has been exhausted.

The Upper Freeport Coal of Monongalia, Preston, and adjoining counties makes an excellent coke, and is especially valuable for mixing with low-volatile coals for coking in by-product ovens, since this coal contracts in passing into coke, while some other coals swell up and thus tend to disrupt the expensive ovens. The average analysis of 1500 samples of this Upper Freeport Coal from Preston and Monongalia Counties gave the following results:

	Per Cent.
Moisture	1.60
Volatile matter	27.80
Fixed carbon	63.04
Ash	7.56
Total	100.00
Sulphur	0.99

The average analyses of 925 samples of coke from the same region gave the following:

	Per Cent.
Moisture	0.80
Fixed carbon	86.54
Ash	12.66
Total	100.00
Sulphur	0.98

A by-product test on a car-load of this coal, made at Indianapolis, Indiana, by the Citizens Gas Company of

that city, in March, 1912, yielded the following results:

		Pounds
Weight of dry coal charged		14,460
Dry coke produced, large pieces	74 35 per cent	10,752
Dry coke produced, small pieces	0 93 per cent	135
Breeze produced	1 58 per cent	229
Total	76 86 per cent	11,116
Yield of tar, 4 36 per cent of dry coal		630½
Sulphate of ammonium, 1 21 per cent of dry coal		173

The splendid quality and wonderful variety of coals in the southwestern half of West Virginia along the lines of the Coal and Coke Railway, the Kanawha and Michigan, Chesapeake and Ohio, Virginian, and Norfolk and Western Railways, are so well known in the markets of the country that they scarcely need any special description. These coals are described in detail and published along with hundreds of analyses in the reports and maps of the West Virginia Geological Survey, a list of which briefly describing each publication can be obtained from the offices of the Survey, Morgantown, West Virginia.

Some of these "Kanawha Splint" coals, like the Coalburg and Winifrede, contain such a small quantity of iron in the ash that the latter is practically white and hence these coals can be used to great advantage as a fuel in the manufacture of snow-white Portland cement. The fusing point of their ash is above 3000° F

The New River and Pocahontas Coals are generally known to the trade as "smokeless" and are specially valuable for steam and bunkering purposes for use on freight and battle-ships, and they make splendid coke.

The total coal deposits of the several counties of the State as figured from the detailed surveys of the several counties already made and from close estimates on the few (7) remaining ones not reported upon aggreate a net tonnage of 105 billion, of which at least 83 billion net tons may be regarded as recoverable coal. The total quantity of coal already mined during the 60-odd years of West Virginia's coal mining history totals only about one billion net tons, or less than 1 per cent of her total deposits. Hence the West Virginia factories and those to be located therein hereafter can be assured of a practically unlimited and cheap fuel supply extending into a far distant future.

Limestone in large deposits of commercial value is confined to the eastern counties of the State, like Jefferson, Berkeley, Morgan, Hampshire, Mineral, Hardy, Pendleton, Pocahontas, Greenbrier, Monroe, and Mercer, although thick deposits occur in Monongalia, Preston, Tucker, Grant, Randolph, and Barbour, belonging to the Mountain or Greenbrier Group. Up to this time the only large quarry operations on the limestones of the State, except for railway ballast and one cement factory at Manheim in Preston County, are located in Jefferson and Berkeley Counties, where vast quantities of the very highest grade of limestone used in the manufacture of plastering lime, hydrated lime, Portland cement, and for flux in iron and glass furnaces, crop out along the Baltimore and Ohio, Norfolk and Western, and Western Maryland, and other railway lines. These limestones are fully described and analyses given in the Survey volume on Jefferson, Berkeley, and Morgan Counties, along with the other minerals of that area including vast deposits of very pure Dolomite.

Iron Ores, of which West Virginia has 200 to 300 million tons, principally in the counties of Hampshire, Hardy, Mineral, Grant, Pendleton, Pocahontas, Greenbrier, and Monroe, are described in Volume IV of the West Virginia Geological Survey, along with the enormous resources of the State in glass-sand, and saline brines, many analyses of all of which are given therein.

Saline Brines along the Ohio River Valley to be obtained by boring to depths of 1000 to 1200 feet anywhere between Moundsville and Kenova, and along any of the tributaries of the Ohio, like the Little Kanawha, Great Kanawha, Guyandot, Twelvepole, and Big Sandy Rivers, are especially rich in other minerals besides common salt; viz., bromine, and calcium and magnesium chlorides, etc. These brines have been operated continuously in Kanawha County for more than 100 years, and for nearly that long in Mason County on the Ohio River, and as a basis for large chemical industries where good coal exists in the immediate hills, or else can be brought by cheap rail or waterborne freights to the immediate doors of the factories, no more attractive sites could be found in the entire country. The composition of these brines is shown by the following analyses reproduced from Volume IV, West Virginia Geological Survey, page 332:

	Parts in 1,000 Parts by Weight
Sodium chloride	60 1762
Sodium bromide	0 2238
Sodium iodide	0 00098
Sodium nitrate	0 00000
Sodium arsenite	0 0000097
Sodium borate	Small amount, not estimated
Potassium chloride	0 5700
Lithium chloride	0 1010
Ammonium chloride	0 0787
Barium chloride (= 46.14 grains per gallon)	0 7447
Strontium chloride	0 2013
Calcium chloride	15 0103
Magnesium chloride	4 9692
Calcium bicarbonate	0 2661
Ferrous bicarbonate	0 0822
Manganous bicarbonate	0 0076
Calcium phosphate	0 0005
Aluminum	Trace
Silica	0 0040
	83 3456
Specific gravity at 15 5° C.	1 0628

The Clay industry of West Virginia is only in its infancy, having been confined principally to the counties of Ohio, Brooke, and Hancock, along the Ohio River front, where are situated some very large sewer-pipe, brick, china, pottery, and other clay-working industries. Good clays and shales for the manufacture of common, vitrified, and pressed brick, however, are abundant in nearly every county of the State, and large clay-working industries are possible in the immediate vicinity of good gas territory, and outcropping coal beds. The succesful potteries at Cameron, Mannington, etc., and the vitrified products made at Parkersburg, Huntington, Weston, and elsewhere in West Virginia, as well as the large and successful brick plants at Charleston, Huntington, Thornton, Hammond, Morgantown, and elsewhere in the State, demonstrate the wide field open for these and kindred investments where the raw materials, like glass-sands, limestones, iron ores, clays, saline brines, etc., are in close physical association with vast deposits of coal and natural gas.

Some Experiments on the Extraction of Radium from American Pitchblende Ores by Chlorination

By Mrs. RAY CABLE and HERMAN SCHLUNDT

THE uraninite in the pitchblende ores of Gilpin County, Colorado, occurs very intimately associated with iron pyrites. Apparently no satisfactory method of separating the uranium minerals from the pyrites by mechanical methods has been developed. Concentration of the ore by the ordinary mill operations results in several products ranging in content of uranium oxide, U_3O_8, from 1 per cent to 25 per cent. The final blending gives three grades: high-grade, containing upwards of 16 per cent U_3O_8; medium-grade, averaging about 4 per cent; and low-grade containing less than 2 per cent U_3O_8. The main body of all grades however is iron pyrites.

The extraction of radium from these ores has been carried out successfully on a commercial scale by methods developed in the U. S. Bureau of Mines. During the summer of 1916 one of us assisted for a time in the laboratory experiments conducted in the Mining Experiment Station of the U. S. Bureau of Mines at Golden, Col., preliminary to plant operations. We were thus brought face to face with some new problems in radium extraction from an ore differing fundamentally from the European pitchblendes in its distinctively high content of sulphide minerals. Subsequently we continued our investigations on these ores in the chemical laboratory of the University of Missouri. The experimental results here presented summarize the results obtained by a new method of extracting radium by direct chlorination of the ore. We are indebted to Dr. R. B. Moore, Superintendent of the Golden Station for the samples of ore used in these experiments.

The Reaction

When the ore is heated in an atmosphere of chlorine, interaction takes place readily. The principal products of the reaction are sulphur monochloride, S_2Cl_2, and chlorides of the metals present. The reaction of chlorine with iron pyrites takes place mainly according to the equation,

$$2FeS_2 + 5Cl_2 = 2FeCl_3 + 2S_2Cl_2$$

and is an example of one of the general methods of preparing sulphur monochloride. By conducting the reaction in a stream of chlorine gas the chloride of iron together with chlorides of uranium appear as a crystalline deposit in the cooler parts of the apparatus, while the more volatile product, sulphur monochloride, can be separated as a gas which is easily condensed and collected in a receiver. Chlorination probably converts the radium into chloride, which, contrary to our expectations, is also carried forward in the current of chlorides, a relatively small fraction only remaining with the unattacked constituents of the ore.

Upon the addition of water to the residue and anhydrous chlorides of the metal a very vigorous interaction occurs. The radium compounds for the most part remain in solution. After filtering off the small insoluble residue, the radium can be precipitated very nearly quantitatively as radium-barium sulphates by adding to the filtrate a little barium chloride solution and its equivalent of sulphuric acid. The addition of sulphate ions to precipitate the radium-barium sulphates is, as a rule, not necessary inasmuch as a small quantity of sulphates is generally produced in the course of the chlorination. The reason for the radium not precipitating in the presence of sulphates when the chlorides are treated with water, we are inclined to attribute to the lack of sufficient barium in the ore. Recent determinations of the solubility of pure radium sulphate conducted by Lind, Underwood, and Whittemore[1] in the Golden Station of the U. S. Bureau of Mines have fixed the solubility of radium sulphate in water as approximately a hundredfold less than that of barium sulphate. Nevertheless the minute quantities of radium in the solutions here under consideration still lie below the solubility product of radium sulphate. However when radium sulphate is precipitated together with a large excess of barium sulphate the solubility of radium sulphate is far below the actual solubility of radium sulphate. Hence precipitation of barium sulphate in quantity a hundredfold or more the solubility of barium sulphate in the solution results also in a practically quantitative precipitation of the radium.

The Ore Samples

Experiments were conducted with the three grades of ore designated respectively low, medium, and high-grade. The radium content of each grade was determined quantitatively by separating the emanation from weighed samples, and measuring the ionization current product by it in standardized electroscopes[2]. The percentage of uranium was computed by multiplying its radium content by the established constant, 3×10^6, for the ratio of uranium to radium in primary uranium minerals. The analytical results thus obtained appear in the tabulated summary given herewith. The percentage of uranium in the high-grade ore was also determined by chemical analysis in the laboratory of the Bureau of Mines and found to be 17.58 per cent U_3O_8, a value in close agreement with the uranium oxide equivalent of 17.45 per cent calculated from the radium content. Since some emanation is continuously liberated from the ore under ordinary conditions of temperature and pressure it is necessary in making radium determinations on samples not previously sealed until equilibrium has been

[1] Jour. Amer. Chem. Soc., XL. 3, March, 1918

[2] For a description of the method and the apparatus used see, Lind, "Practical Methods for the Determination of Radium," Jour. Ind. and Eng. Chem. 7, 406 and 1024 (1915). See also Schlundt and Moore, Jour. Phys. Chem. 9, 320, (1905)

attained to determine the emanating power on another sample. We found that the emanation lost in the cold ranged from 6 to 9 per cent of the total in the different grades. The values for the radium content given in the table are, of course, based upon the equilibrium quantity of emanation.

In making the radium determinations the emanation was separated by dissolving suitable quantities of the finely ground ore in 40-per cent nitric acid and collecting the gaseous products in a gas burette over a hot solution of sodium hydroxide. The interaction of hot nitric acid with the sulphides of the ore produces several oxides of nitrogen, one of which, nitric oxide, is absorbed only very sparingly by the alkaline solution. As a result the volume of gas in determinations where samples of about a gram of ore were required was found to exceed the capacity of our gas burettes. This difficulty in the usual procedure may be overcome either by largely displacing the air in the reaction flask with oxygen before introducing the nitric acid, or by admitting oxygen into the burette from time to time during the progress of the reaction. Oxygen converts nitric oxide into nitrogen peroxide, NO_2, which is readily absorbed in the solution of lye.

The Experiments

For chlorination, the ore in charges of 30 to 35 grams was spread out over about one-third the length of a 1½-meter piece of hard-glass combustion-tubing of fully 2 cm. diameter, fitted at both ends with one-hole rubber stoppers. The ore charge was heated in a long combustion furnace of the type usually employed for combustion analysis of organic compounds. On the one hand the tube was connected with a tank of liquid chlorine, and on the other with a condenser and receiver. A wash-bottle containing sulphuric acid was placed in the train next to the chlorine tank, and this was followed by a T-tube dipping into mercury which served as a vent for the escape of chlorine in case the products of the reaction ever clogged up the outlet end of the tube. A plug of glass wool was inserted near the outlet end of the tube to stop small amounts of metallic chlorides that are apt to be swept along by the vapors of sulphur monochloride when chlorination is rapid. In the early experiments the ore charge was placed in several porcelain boats, but after finding that only a small fraction of the radium remained with the unattacked residue the boats were no longer used.

The chlorination was conducted by heating moderately at first with a slow stream of chlorine passing until rapid reaction starts which occurs before low redness is reached. The supply of chlorine was then materially increased and the temperature gradually raised to low redness. The metallic chlorides formed are deposited along the tube beyond the heated portion and sulphur monochloride passes on to the condenser if the cooler part of the tube is kept at a temperature above 137°, the boiling point of the monochloride.

Chlorination of the low-grade ore was at first carried out with samples ground to pass through an 80-mesh sieve, but when it was found that this degree of comminution is not necessary for complete chlorination, ore of 20-mesh was used in the subsequent experiments with medium and high-grade ores. Several of the chlorinations lasted three to five hours but in most of the experiments the flow of chlorine was so regulated that a charge of 35 grams was completely chlorinated within an hour. Turning the tube a little with an occasional tapping saves time.

When the tube had cooled it was taken from the furnace and the contents washed out with water or very dilute hydrochloric acid. After boiling, the insoluble residue, the tailing was filtered off, washed, ignited and weighed. The filtrates were again heated to boiling and radium precipitated by adding a few cc. of a 10 per cent solution of barium chloride and an excess of sulphuric acid. Three or four days after precipitation the sulphates were filtered off, ignited, weighed, and finally assayed for radium. The liquors were diluted to 500 cc. and samples of 200 cc. were boiled and sealed up for quantitative determinations of radium remaining in solution.

Complete duplicate experiments were conducted with each grade of ore. The recovery of radium in the sulphates, and the losses of radium in the tailings and liquors were determined by the emanation method. Carefully standardized electroscopes[3] of the interchangeable type[4] designed by Dr. Lind of the Bureau of Mines were used in the radium determinations, and use was made of the apparatus for boiling off and transferring the emanation described by the same author. Small samples (20 mg.) of the radium bearing sulphates were fused with mixed carbonates of sodium and potassium in small platinum boats which were then stored in sealed tubes for definite periods and finally decomposed with 1:1 nitric acid in an apparatus for collecting the emanation quantitatively. For determinations of radium in the tailing samples, about half the quantity of insoluble residue from 35 grams of ore was fused with mixed carbonates in platinum crucibles, the melt poured out into an iron mortar, powdered and then sealed in thin glass bulbs. After several days of storage the accumulated emanation was separated by decomposition with nitric acid. Details of the procedure and calculation of the results are given in some of the references cited.

The Results

The experimental results are summarized in the Table I.

The recovery of radium is satisfactory for each grade of ore, and the radium content of the sulphates lies well within the limit required for further concentration by fractional crystallization after conversion of the sulphates into chlorides. The concentration ratios were computed by dividing the figure for the concentration of radium in the sulphates by the radium content of the grade of ore from which the sulphates were recovered. The radium losses given for the liquors are probably too low inasmuch as our method of testing simply accounts for the radium actually in solution, and does not include possible traces of radium carried in suspension. We are, therefore, inclined to assign the percentages of radium unaccounted for at least in large part to this avenue of loss because a second

[3] Leaming, Schlundt, and Underwood, Trans. Am. Electrochem Soc., 30, 375, (1916)

[4] Loc. Cit.

precipitation of barium sulphate in the liquors invariably gave a "second" sulphate of higher radium content than the loss found in the liquors by our method of testing. We are convinced that the loss of radium in the sulphur monochloride is negligible. In one experiment the residue left upon evaporation of the chloride when tested by the ordinary alpha-ray method showed no activity whatever.

It would be interesting to ascertain whether the radium in the deposit of metallic chlorides can be further concentrated by volatilizing the anhydrous chlorides again. Perhaps the radium would then remain for the most part in the non-volatile residue.

We hope to extend the investigations in the near future to larger samples of ore.

A few chlorination experiments with carnotite ore did not give results of promise for a method of extracting radium.

The chlorination experiments with low-grade ore represent one phase of a more extended investigation on the extraction of radium from pitchblende ores to be submitted by Mrs. J. Ray Cable as a thesis in partial fulfillment of the requirements for the degree of Master of Arts, University of Missouri.

Chemical Laboratory, University of Missouri

TABLE I. SUMMARY OF RESULTS

	Grade of Ore	Low	Medium	High
2	Radium content of ore, parts per billion	3.43	8.312	49.27
3	Uranium content of ore, expressed as U_3O_8	1.20%	2.92%	17.45%
4	Weight of ore used	32.0 g.	35.0 g.	35.0 g.
5	Weight of tailings	3.30 g. = 10.32%	0.795 g. = 2.27%	3.53 g. = 10.09%
6	Total radium in ore sample	109.8×10^{-9} g.	290.9×10^{-9} g.	$1,724.5 \times 10^{-9}$ g.
7	Weight of sulphates recovered	0.0938 g.	0.237 g.	0.635 g.
8	Radium recovered in sulphates	102.5×10^{-9} g.	267.1×10^{-9} g.	$1,615 \times 10^{-9}$
9	Radium recovered in sulphates	93.34%	91.78%	93.68%
10	Concentration of radium in sulphates—parts per billion	1,084	1,127	2,543
11	Concentration ratio	316:1	135:1	51.6:1
12	Radium losses:			
	(a) In tailings—emanation method	1.954×10^{-9} g. = 1.74%	4.36×10^{-9} g. = 1.53%	56.6×10^{-9} g. = 3.29%
	(b) In liquors—emanation method	4.23×10^{-10} g. = 0.34%	1.49×10^{-9} g. = 0.51%	4.43×10^{-9} g. = 0.26%
13	Radium unaccounted for	4.58%	6.18%	2.77%

Hydro-Electric Power in Relation to Industry*

By J. A. JOHNSON

THIS country is undoubtedly on the eve of a great development of its hydro-electric power resources. If it isn't, it ought to be. The time is ripe for it and conditions demand it. The nation is facing the gravest crisis in its history, not only in a military sense but in a political and economic sense. Our immediate problem of course is to win the war, but after the war is over there will be other problems to solve. Labor, for instance, has undoubtedly got to be reckoned with, and there will be immense problems involving the control of industry by the government and the attitude and spirit in which that control is to be exercised. Are we to go in for government ownership and operation of industry, or are we not? And if so, to what extent and how?

These and many other questions are demanding answers, and it therefore seemed to me that it would be far more profitable and useful for us to discuss this phase of the problem, than merely to be listening to a more or less instructive address on power-plant design. I therefore concluded that I would try to discuss the subject from the standpoint of the utilization of the power, that is, the relation of hydro-electric power to industry.

Essential Factors in Industry

In any industrial or manufacturing undertaking there would seem to be about five major factors which largely determine its location and its success or failure after it is located. These are—

1.—Raw material
2.—Transportation
3.—Power
4.—Labor
5.—Market

Raw Materials must be transported to the plant, then transformed by means of power and labor into the finished product and again transported to the market. We are to consider the relation of the factor of power, principally hydro-electric power, to the other four, raw materials, transportation, labor and market.

Industries may be broadly divided into two general classes:

1.—Those in which the cost of power is a large part of the cost of the product.
2.—Those in which the cost of power represents only a small percentage of the cost of the product.

Power developments may also be broadly divided into two general classes:

1.—Those having a continuous steady supply of water, such as Niagara Falls, and which are therefore capable of delivering power continuously;—and
2.—Those having a more or less variable supply of water, and which are therefore incapable of supplying continuous power.

In the first class of industries are those using electric power in large quantities for electrochemical and electrometallurgical processes. In such industries a low power-cost is usually essential to meet competition in the finished product from other more favorable sources. Such industries usually work with continuous processes, or at least processes requiring continuity for highest efficiency, consequently require power continuously, and therefore necessarily seek power sources of the first class, which can continuously supply the power continuously needed.

In the second class are those industries using power for mechanical purposes, that is, for driving machinery. Such industries usually operate for eight to ten hours per day only, hence have a low load factor, that is, they require their power only intermittently. Such industries therefore are adapted to utilize hydro-electric power sources of the second class, which have an inherently low "supply factor," as it might be called.

Now, this country is going ahead and developing its

*A paper read before *The Engineering Society of Buffalo* on March 13th, 1918.

hydro-electric powers. What is it going to do with them after they are developed? How are they going to be used? Are continuous powers to be frittered away and wasted in losses in long transmission lines and in supplying the intermittent demands of intermittent industries, while perhaps continuous industries are left to operate inefficiently on the "leavings" in the form of intermittent powers and the intermittent off-peak or secondary capacity of the continuous developments which have been primarily used for intermittent service? Or, is an intelligent effort going to be made so to co-ordinate the requirements of industry with the characteristics of the power developments that each development will be utilized in the most efficient manner?

If the problem were as simple as it sounds, it would be a fairly easy matter, but unfortunately or otherwise, it is not so simple. Hydro-electric developments are extremely diverse in character. They range all the way from plants having a "supply factor" of 100%, i. e. capable of delivering their full output continuously to those whose "supply factor" is perhaps no greater than 10% or even less. Furthermore, the time factor enters into the problem. Some plants, having practically no storage, and located on variable streams, are obliged to deliver their power practically as the water flows. They are, therefore, subject to great seasonal variations, and other irregularities of flow, which place a limit upon the extent to which they can be developed economically. In order to utilize such developments to the best advantage, they have to be supplemented by some other source of power, such as steam plants, in order that the industries using power may be assured of a reasonably constant power supply throughout the year. In cases where the cost of development is not too great, this plan is feasible and is often employed.

Other plants there are, which can be developed with a small amount of water storage capacity. Such plants can utilize a slightly larger proportion of the total flow and can themselves take care of load fluctuations of short duration, such as the demands of eight to ten hour customers, through their ability to store up water during the night for use during the day. There are already hundreds, perhaps thousands of such powers developed, often for the driving direct by water wheel of small manufacturing plants. Many a small town is built up around just such a power. There are doubtless thousands of others, many of them in inaccessible locations, which might be developed and the power transmitted to the nearest towns there to be used for similar purposes. Such powers can probably best be developed in connection with larger developments in their neighborhoods, and probably will be developed to a greater and greater extent through the application of the automatic generating station which has now been brought out by one of the largest electric manufacturing companies. This, by the way, is an extremely interesting innovation. Such stations require no attendance except periodically, and are cut on and off the circuit automatically through the agency of automatic switches operated by the water level in the forebay. In my opinion such stations are destined to play an important part in the development and utilization of our small water powers, of which we have a vast number, aggregating a very large amount of power.

Still other powers can be provided with vast storage reservoirs capable of storing up a large proportion of the total flow of the stream for months at a time, thereby enabling the power plant to operate nearly or quite continuously throughout the year. Sometimes a whole river can be so controlled and regulated by means of large reservoirs at the head waters which can be created by storage dams, thereby enabling a whole series of power plants located at different points on the river to be operated continuously, all using the same water as it flows down toward the sea. In this way the enormous quantities of water liberated by the melting snows of spring can be stored for use during the dry summer months and the fall rains for use during the frozen winter months.

Cost of Developing Hydro-Electric Power

Water powers also vary greatly as to their costs per horsepower developed. Nothing is more false than the popular belief that water power is necessarily cheap because water is a free gift of nature.

The cost of developing a hydro-electric power proposition may be anywhere from about $40.00 to $200.00 per horsepower. Developments costing less than this minimum are few and far between, and above about this maximum they cease to be commercially practicable under present conditions.

Hydro-electric developments also vary greatly in location. Some are located in the midst of densely populated districts, others more distant from civilization, and still others far away in the inaccessible wilderness. Victoria Falls, South Africa, one of the largest if not the largest single possible source of power in the world, is located so far from all human activity that it has thus far been impracticable to develop it. On the other hand, our own Niagara, located though it is in the very midst of the most thickly populated portion of the United States and Canada, is as yet only developed to a fraction of its possible capacity. In fact, water powers vary greatly in location with respect to all four of the factors of industry, raw material, transportation, labor and market.

It is clear then that hydro-electric powers are of infinite variety as to characteristics, cost and location. The problem therefore of co-relating industries with hydro-electric power is a complicated one.

Nevertheless, if our natural resources are to be conserved to the greatest extent, it is necessary, not only that our water powers shall be developed and put to work, but also that each power shall be put at the work it is best suited to perform. This applies not only to water power, but to steam power as well. It is an economic waste to use low-cost power for purposes for which higher-cost power would serve equally as well in those cases where the cost of the product would not be materially increased thereby.

It would seem worth while, therefore, to inquire to what uses the several types of hydro-electric developments should be put for the greatest economic benefit. Let us then consider briefly the several types of hydro-electric powers as related to industrial use.

Types of Hydro-Electric Development

First, consider a power located in the wilderness at a considerable distance from all four of the factors of industry. How is it to be utilized? Obviously only in

exceptional cases can the industry go to such a power, the exceptions being when some one or more of these factors can conveniently and cheaply be brought to the power along with the industry. In most cases such a power can only be utilized at all by transmitting it to the neighborhood of a sufficient number of the industrial factors to enable it to be utilized economically. Such transmission costs money, introduces power losses and adds to the cost of the power, and the power so transmitted must be able to compete with power from other sources such as coal, gas or oil. Power which has been transmitted any great distance is usually too greatly increased in cost thereby for use by the continuous class of industries mentioned, hence a market for it must be found among public utilities and industries of the intermittent class to whom the cost of power is not of vital moment.

As an example of a power of this general character I would mention the Salmon River Power Co. Such powers are often unsuited to the use of industries of the continuous class not only on account of cost, but also owing to their inherently low "supply factor" characteristic. The Salmon River Co. is such a one, as it is upon a stream of very variable flow, and could be developed at all only by resort to storage. This plant is located about forty miles north of Syracuse, near the little town of Altmar, N. Y., and as you doubtless all know, is now a part of the system of the Niagara, Lockport & Ontario Power Co., supplying a general industrial and public utility load, a service to which it is eminently well suited, and about the only type of industry which is suited to it.

There are many such powers yet undeveloped, for the reason that they are so far from civilization that they cannot compete in the market with power from coal, but it is quite possible to conceive that government control may, by regulation of the uses to which coal and other consumable resources may be put, force the development of such powers for use by public service and manufacturing industries to which the cost will not constitute an excessive burden if the competition of coal is eliminated. The development of such powers would, in the natural course of events, await the increase in the price of coal, but if the government fixes arbitrarily the price of coal, it may also determine to what uses it may be put, under which conditions inaccessible powers could and should be developed. The coal would thereby be conserved for those uses for which electric power is too costly.

In view of the present situation it does not seem at all improbable that such a situation may come about in the not far distant future.

Now let us consider the power which is located near one or more of the four factors of industry. Such powers may be and are of infinite variety as to their size and characteristics, and also as to the particular factor or factors to which they are accessible.

Take for instance the Shawinigan Water & Power Company at Shawinigan Falls, Quebec. Located about midway between Montreal and Quebec City, on the end of a branch of the "Great Northern Railway," it had, at the time of its first development, neither raw material, transportation, nor nearby market. Montreal and Quebec would appear to offer the best outlets for the power, and transmission lines were built to the former, but the location, only about twenty miles from the St. Lawrence River, and the abundant supply of cheap labor from the French Canadian population, soon overcame the apparent drawbacks, and large electrochemical industries proceeded to locate close to the development. Railroads were built to the St. Lawrence at Three Rivers, thus supplying the two factors of cheap transportation and labor, which, coupled with cheap power, were sufficient to overcome the lack of raw materials and a nearby market. Shawinigan Falls is now a thriving industrial city, and the power of the St. Maurice River is being used at the source in the manufacture of the manifold electrochemical products which have become so essential to modern civilization.

Consider also Niagara Falls. Here is a power almost unlimited in quantity, absolutely continuous in character, fairly cheap to produce, with abundant transportation and labor immediately at hand, and practically in the midst of the market for its products. How should that power be used in order to produce the greatest benefit to the nation and to mankind? Obviously it is designed by nature for use in those industries which require continuous power, that is, for electrochemical and electrometallurgical processes. In what way can a kilowatt-hour of Niagara power be used for the greatest good? Is it desirable that it be carried to some distant point such as Windsor or Sarnia, with a loss of 15 or 20 per cent, and there dissipated in wasteful and extravagant lighting under what amounts to a government subsidy? Should it even be sent to Toronto to be used in the pumping of water at a cost greater than could be accomplished by steam power? Is it even desirable that this power be sold for public service purposes near at hand at prices so low as to promote carelessness and wasteful extravagance? Would it not be better to distribute this power for such purposes only to such distances as can be done economically, in proper competition with other sources, and to sell it only at such prices as will promote economical use, and to utilize the greater part of it at the source in the manufacture of abrasives, ferrosilicon, fertilizers and a thousand and one other products which are being made at Niagara Falls, N. Y., and which are of such importance in the modern industrial world? Modern civilization is dependent on these things. Take ferrosilicon, artificial abrasives, and aluminium away from the automobile industry, for instance, and what would be the result? Quantity production, as we now know it, would be an impossibility. We have it on authority that weights would be increased over 80%, production would be reduced by about 80%, and prices would go out of sight. The same would be true in greater or less extent all down the line. Practically everything we use would be affected, even to our food, into which these things enter in the form of farm machinery, tractors, fertilizers, etc.

Results of Failure to Co-ordinate Power and Industry

The fallacy of the thing has been made fairly obvious by the demands of this war. What has happened? Why, people have been exhorted to reduce their lighting in order that industries making munitions, principally ferrosilicon and similar products, might have the power. Street lights have been slashed right and left for the same purpose. Streets have been left in darkness till

late at night, whole sections of cities have been cut off from their lighting circuits in the day time and deprived of the use of their electric irons, toasters, vacuum cleaners, etc., for hours at a time in order that electrochemical industries might have the power. On the one hand people are being exhorted to use power, to buy electric power-consuming devices, and on the other are being deprived of the power that they have been exhorted to use. To be sure, this is a war condition, but war or peace, is the principle any different? Will not the same conditions exist ultimately under peace conditions?

Well, how are we going to accomplish this co-ordination of power and industry? Shall we depend on public ownership to do it? Public ownership is doing just the opposite. Most of the economic crimes which have been committed in connection with hydro-electric power have been committed by public ownership.

Just a word as to public ownership. Its slogan is "Power at Cost." Well, what is "cost"? It is likely to be something quite different under public ownership from what it is under private ownership, but you're not supposed to know that. You are supposed to be hypnotized by the thought of getting power at cost and made extremely joyful at the prospect of depriving some criminal corporation of its ill gotten gains. Well, what happens?

In a private corporation no project is entered into without thorough study and investigation of plans, methods, costs, probable earnings, etc., etc. The success or failure of the undertaking depends on the accuracy of these estimates, as there is always competition to be met.

Under public ownership and the "power-at-cost" principle, what happens? Well, it's "power at *cost*." The people have got to foot the bill anyhow, so why worry about the cost and why go to all the labor and pains to make careful estimates and well considered plans? Rough estimates will do—all they are for anyhow is to serve as a basis for an appropriation. Make them as low as possible so as to make it look attractive, because after the work is started it will have to be finished anyhow, whatever it costs. And, as to plans, why bother about extensive investigations; probably the different schemes will not differ much in cost anyhow, and as the cost has got to be paid, whatever it is, why go to all that unnecessary work. It is very easy to explain to a gullible public that the high cost was due to the increase in the price of materials and labor or something else. The result is likely to be "Power at Cost" with the accent on the *cost*. The legitimate profit which the private corporation would make by careful and efficient management is probably more than swallowed up in the wasteful and extravagant methods of the publicly owned undertaking, but the public doesn't know that, so is perfectly happy—for a while.

As a matter of fact it is well known that long distance power transmission enterprises have not been particularly successful financially even under private ownership, such profits as have been made being small even under the most economical management possible. That any substantial reduction in actual cost to the consumer in such enterprises can be effected by public ownership is extremely unlikely.

There are ways, however, in which the illusion can be kept up. For instance, in a certain city where public ownership prevails, power is sold to lighting customers at two cents per kw.-hr. up to a certain point, with a reduction to one cent for all excess. The waterworks department of this same city is required, against its own desire, to use large amounts of electric power for pumping, and for that service is charged the equivalent of 2⅝ cents per kw.-hr. Also this same city has installed an extensive and extravagant street lighting system which also forms a very convenient dumping ground for the excess power costs. The tax rate of this city this year was about thirty mills, of which one mill or about 3 per cent was to pay for deficits on its publicly owned utilities.

A second objection to government ownership—unless it is complete, an absolute monopoly—is its injustice. All public service corporations are subject to government regulation whenever the government chooses to exercise it. For the same government to enter into competition with the same corporations which it has the power to regulate, is manifestly unjust and leads to all sorts of abuses for which there is no redress.

It is impossible to keep politics out of publicly owned utility, or to keep the utility out of politics. A power monopoly, particularly, offers too easy an opportunity for unscrupulous politicians to establish and maintain undue political, social and economic power over a large population. With such an instrument being used for political purposes its policies, purposes and methods take on a political complexion, and even problems which should belong solely to the realms of engineering and economics are decided by political considerations.

For instance, the transmission of Niagara power to Sarnia, a distance of nearly 200 miles, where they had a perfectly good, brand-new, up-to-date steam-turbine electric plant, which was deliberately put out of business thereby, can hardly be justified on either engineering or economic grounds.

Another objection to public ownership is its apparent inability to keep ahead of the game. It is always scurrying to keep up with the procession. It falls into the never ending circle of scurrying on account of lack of foresight, and lack of foresight on account of being always scurrying. Consequently it is always facing a crisis of some sort due to its failure to prepare in advance. This condition may be partly due to inferior personnel, partly to playing politics, and partly to lack of authority to spend money or ability to obtain authorization from the legislative body for the expenditure of money for future requirements; but whatever the cause, it is a condition which exists.

However, there is a strong trend toward public ownership. If we are to have it, let's go into it with our eyes open, and when we are in it, let's insist that it be open and above-board. Personally I do not think we can look to public ownership for the solution of the problems of correlating hydro-electric power and industry.

What then can be expected of private ownership? I believe private ownership has done very well. The bulk of the power generated at Niagara, on the American side, is used for the purposes nature intended. A certain amount, to be sure, is transmitted away for public utility use, but this is perfectly legitimate, as it is right and proper that enough of the power should be used in this way to supply the reasonable needs of the people within reasonable transmission distance. Also a steam

station has been built to supply further requirements in this respect. This also, in my belief, is quite as it should be. Steam power is quite suitable, and can be supplied at reasonable cost commensurate with the service rendered, for such industries and utilities as are, or will be, located at Buffalo.

Further development at Niagara should be reserved for those industries requiring large quantities of cheap continuous power for the manufacture of important—nay, indispensable—materials of industry, materials which are so vitally needed at the present time.

What, then, of the government? Is there no function which it should perform in this important matter? I believe that there is. It should see that water power is developed with reasonable economy and utilized to the best advantage. It should establish a commission on this correlation of hydro-electricpower and industry, which should make a thorough study of the water powers of the country with a view to their early and proper utilization. It should seek to bring together industries seeking power and water powers seeking customers, to the end that the water powers of the country may be put to those uses to which they are individually best adapted, and that industries may find inconsumable power sources suited to their needs. So far as water powers on the public domain are concerned, it should promote their utilization under conditions sufficiently favorable to attract capital and under such restrictions as may be necessary to guard the public interest. In all these matters it should adopt a constructive policy designed to promote in every legitimate way the proper and immediate development and utilization, under private ownership, of the country's vast water power resources.

The Possibilities for the Development of Chemical Industries in the Southern States

By RICHARD K. MEADE

ALL things in the South either begin or end with the Civil War. When Lee surrendered at Appomattox, the old South died and the new South was born. The old South was primarily an agricultural community. While here and there a Welsh, Swedish or German colony scratched the hillsides for iron ore and smelted this with charcoal in primitive furnaces, the great mass of the population was dependent on agriculture for a livelihood. There was almost no manufacturing carried on in the States comprising the Confederacy. The cotton which was raised was sent north to be woven into cloth by the looms of New England and vast other sources of raw material lay untouched.

With the fall of the Confederacy, the new South was born. The child naturally inherited some of the characteristics of the parent, but it also began to develop talents of its own, and while the South is still a great agricultural community, producing as it does more than half of the total value of the farm products of the country, its mineral and other resources are rapidly being developed and turned into manufactured articles in Southern plants and workshops.

The new South has passed through all of the phases of childhood to its present well-developed manhood. The reconstruction era was its cradle period and the closing years of the eighteenth century found it just beginning to walk. Until quite recently, its young men who were technically inclined, discouraged by the few openings for the display of their skill and energies in the states of their birth, emigrated to the West and opened up mines or came north and dug tunnels under the Hudson River or fixed nitrogen from the air at Niagara Falls.

With nearly a third of the population of the United States within the South, the total capital invested in manufacturing throughout this whole region is but little greater than that invested in such enterprises in the State of Pennsylvania alone. The six Southern states, Virginia, North Carolina, South Carolina, Georgia, Alabama and Tennessee, which are richest in mineral resources, have less capital invested in manufacturing than Massachusetts, and yet the latter state is almost without any natural advantages in raw materials.

In considering the South, therefore, as a manufacturing center, we must view it rather as to its future possibilities than from any past performances, in spite of the fact that the growth of manufacturing in the new South during the last two decades has been rapid.

There are now manufactured in the Southern states a considerable amount of iron and all of the cement which is needed in this territory. The coal dug from Southern hillsides today is greater than that mined throughout the whole United States twenty years ago. Practically all of the phosphate rock in this country comes from the South and the oil wells of this section produce more than half of our petroleum.

At the risk of boring the reader by enumerating well-known resources of the South, it may be said that this section grows the entire cotton crop of the country. About half the standing timber of the United States is found within its borders. It produces three-fourths of the sulphur of the world and dominates the world's sulphur trade. It furnishes a third of the world's output of oil and scientists put the possible production from existing Southern fields at more than four billion barrels of petroleum. The Southern coal fields extend over 88,000 square miles, a coal area many times greater than that of the French provinces, desire for which excited Prussia to war in 1871. In fact, the Southern coal area is twice that of Europe and contains approximately three-fourths of the coking coal of our nation. Over 5,000,000 horse power await the harnessing of Southern streams. The South is the greatest producer of bauxite for the manufacture of aluminium and of barytes for the production of chemical pigments.

The question of the better distribution of chemical and metallurgical industries throughout the country, so that instead of being located along the Atlantic Seaboard where they would be subjected to easy capture on invasion has been so thoroughly discussed by the press during the last two years, that it is hardly necessary in this short article to do more than call attention to the fact that the Government has located both its powder plant and its nitrate plant within the South far removed from the Atlantic Seaboard. Anyone who has crossed the towering ramparts of the Allegheny Mountains to either one of these sites, can bear testimony to the ease with which these localities could be defended.

Power and Fuel

The primary consideration in the establishment of electrochemical industries must of necessity be the cost of power. In the manufacturing sections of the North, where fuel is comparatively dear, practically all electrochemical industries are dependent upon water power. In certain parts of the South, however, very cheap fuel is obtainable and in such sections steam power could, by the installation of efficient power plants, be put on a cost-footing favorable with water power.

In view of the high cost of developing water power, and the fact that most chemical industries had rather purchase this than go to the expense of developing water power themselves, it would seem that for those who are using a moderate amount of electrical power, there would be great possibilities in the utilization of some of the cheap fuels of the South in this direction. The first cost of even the best steam plant will be far below that of the development of the average water power.

Cheap coal is obtainable nowhere just now, but when conditions are favorable, power plants located in the coal fields of the South can, if properly equipped and managed, furnish power at a figure not entirely out of the competition with water power, particularly when the cost of the development and maintenance of the latter is considered and properly taken care of in estimating the price of such power. At Kingsport, Tenn., there is a large steam-power plant which furnishes current for several chemical and electrochemical operations in that section. It is estimated that under normal prices for coal and labor, current can be produced from coal in favorable localities in the South for about three mills a horsepower-hour which is equivalent to about $30.00 a horsepower-year.

To those, however, who feel that they must have water power in order to put their process on a commercial footing, the South offers plenty of undeveloped power. In this connection it might be well to point out that in the mountainous portions of eastern Tennessee, western North Carolina and South Carolina, northeast Georgia and northeast Alabama, the rainfall is greater than that in any other section of the United States and that in this region the climatic conditions are ideal for the maintenance of power transmission lines. The great power streams of the South are the Cumberland, Tennessee, Coosa, Ocmulgee, Saluda, Yadkin, Broad, Catawba, Roanoke, James, Kanawha, New, Pee Dee, Savannah, Tallapoosa, Neuse and Cape Fear.

The greatest power development in the South has been in southeastern North Carolina on the Saluda, the Broad, the Catawba and the Yadkin Rivers. As we have stated it is estimated that the undeveloped power in the Southern rivers amounts to at least 5,000,000 hp. This is about ten times the power now developed at Niagara Falls and is about equal to all the water power at the present time developed in this country. Of this latter, however, not more than 25 per cent is used by manufacturers and a still smaller portion by chemical manufacturers, the lion's share being employed for public utility purposes such as lighting and street railways.

In the territory where the coal fields of Virginia, Kentucky and Tennessee join, is to be found probably a greater proportion of mineral wealth, including salt, than underlies any other section in the world, and the coal here is of the very best grade for steam purposes. It can usually be obtained for $1.00 per ton at the mine. This and also the Birmingham locality and the lignite fields of Louisiana would seem very promising sections in which to establish electrochemical industries employing steam-generated current or chemical plants in which fuel is a considerable item.

Natural gas occurs at numerous points in the South, and West Virginia was the birthplace of the industry in America. Most of this gas now utilized in ways profitable enough to make its employment for power for electrochemical work out of the question. In northern Louisiana, however, we have the great Caddo gas fields and in Texas the Corpus Christi gas district. The Caddo gas is 95 per cent methane and the geological indications are that a supply of long duration is obtainable here. The gas from this field is now used only for domestic and small manufacturing purposes but here would seem to be obtainable cheap power by utilizing the gas directly in gas engines. Incidentally limestone is found close at hand and of course salt occurs in large quantities in southern Louisiana.

Basic Raw Materials

Coming next to the question of the supply of those basic raw materials which play so prominent a part in the chemical arts generally, such as coke and coal products, salt, sulphur, limestone, wood, etc., we will see what a vast storehouse of these the South really is.

We have mentioned the unlimited supply of coal to be found here. Coke is manufactured pretty generally throughout this area, principally in bee-hive ovens. There are some by-product plants, however, notably those around Birmingham, Ala. While, of course, present outputs probably are contracted for, in normal times benzol and toluol could be obtained from these sources, and no doubt other by-product ovens will also follow in the course of time. Edison built his own plant at Woodward, Ala., from which he obtained benzol for his phenol. The South now recovers about 20 per cent of benzol produced in the country.

Limestone, the basis of many chemical and electrochemical industries, is found in beds extending in an almost straight line through West Virginia and Tennessee, eastern West Virginia, the northern corner of Georgia and central Alabama. Another bed extends through central Tennessee and Kentucky, almost the whole of Missouri and the northern part of Arkansas is also underlaid with limestone. A soft limestone or marl also occurs in central Florida. Both high-calcium

and high magnesium limestone are found in this territory and high-grade lime is obtainable from both varieties. Lime from the Virginias is shipped to Niagara Falls for the electrochemical industries and to the chemical plants in New Jersey.

Salt is now produced in Louisiana, Virginia, Texas, West Virginia and Oklahoma to the value of about $1,000,000. The supply in both Virginia and West Virginia is near water powers available for development and in a locality where fuel is cheap. The deposits themselves are practically of unlimited extent. The Weeks Island, La., salt has a purity of over 99½ per cent sodium chloride, while the West Virginia brines contain considerable bromine and calcium chloride, both of which are recovered and marketed. Soda-ash and soda products are made at Saltville, Va., by the Mathieson Alkali Works, one of the largest producers of such chemicals in America.

Sulphuric acid is the basis of so many chemicals that a supply of this is almost essential to the establishment of a chemical industry in any section. As I have said, Louisiana controls the sulphur trade of the world. Also the largest by-product sulphuric acid plant in existence is at Ducktown, Tenn., in a region abounding in mineral resources. Owing to the fact that plants which sold acid to fertilizer factories, at the outbreak of the war diverted their outputs to munition plants, many of the large fertilizer manufacturers in the South were either forced to build acid chambers, or else found it profitable to do so. The result of this will be that with the end of war there will be a very large over production of sulphuric acid in the South.

Virginia has long been known as the most important domestic producer of pyrites, the value of the output of its mines now being over three-quarters of a million dollars. Georgia also produces some pyrite and there are important undeveloped deposits of this mineral in both of the Carolinas. The only domestic producer of arsenic direct from its ores is located in Virginia.

As I have said, the South has over half the standing timber of the country and this latter comprises both hardwood suitable for distillation and the soft woods for pulp, paper and cellulose compounds. The recovery of turpentine from pine tags is now practical and the South has always been the important domestic producer of this material. Tanning extracts are also important Southern products. Those chemicals made from cotton and crude and refined oils made from cotton seed, including the hydrogenation products of the latter oil, should of course form important Southern industries. Important deposits of fuller's earth for cotton-oil purification are found in Florida which is the leading producer in the country and also in Georgia, Texas and Arkansas.

Special Resources

Many plants of medicinal and industrial value now supposed to be only indigenous to certain foreign climes can be raised profitably in the South. The castor-oil bean is one of them and I believe is to be extensively raised this season to furnish oil for aeroplanes. Medicinal plants which can be grown in the central South are digitalis, Indian hemp, hydrastis, belladonna, gentian, horse mint and a host of others. Camphor is now grown along the gulf coast and in Florida and even tea has been raised in South Carolina.

Red and brown hematite ores extend in an almost unbroken belt from Virginia to central Alabama. The red ores carry considerable carbonate of lime and are hence known as self-fluxing ores. For the production of ferro compounds from these ores, we have, in regions where cheap water power abounds, many of the necessary minerals. For the production of ferro-silicon, quartz and quartz sand are found in many parts of the South, notably Virginia, Georgia and North Carolina. Very pure quartz in massive deposits can be found in the latter state. A large part of the titanium now used for steel making comes from Virginia and in the neighborhood from which the present supply is obtained numerous undeveloped properties occur. Chrome ore for the manufacture of ferro-chromium is found in North Carolina but so far the deposits are undeveloped, or for that matter even thoroughly explored, so it is hard to say what the value of these is. Molybdenum occurs in Texas and is now being mined in that state. The phosphate rock for the present supply of ferro-phosphorus, of course, comes from Florida and Tennessee. Extensive manganese deposits occur throughout many parts of the South, notably in Georgia, Arkansas and Virginia. So far, however, none of these deposits has been very extensively developed although they unquestionably represent possible sources of this metal of great value.

The South has long been recognized as the big producer of bauxite, the ore of aluminium. Practically all of this ore, however, has been sent North for working into the metal until recently when the Aluminum Company of America began developments in North Carolina. Arkansas now produces about 90 per cent of the bauxite of the country, while the balance comes from Tennessee and Alabama.

The phosphate resources of Florida and Tennessee are too well known to need more than mention here. It may be said, however, in passing, that the South is the largest user of fertilizer in the country, yet it has purchased its nitrogen from Niagara Falls and Chile in spite of the immense deposits of limestone and coal which traverse this section and of the fact that its inhabitants claim that Southern air is purer than that found anywhere else in the world.

Practically all of the barytes now used in American plants comes from the South largely from Missouri, Tennessee and Georgia. No doubt when Austrian ores again enter this country, the plants along the Atlantic Seaboard will be supplied from this source but there is no reason why local manufacturing plants should not develop in the states mentioned for the manufacture of barium compounds. Fuel and labor here are cheaper and the necessary zinc for lithophone can be found in southwestern Virginia and eastern Tennessee. I believe that the zinc manufactured here is purer than that found anywhere else in this country.

As to other minerals, Georgia produces more asbestos than any other state; Kentucky furnishes fluorspar; Alabama, North Carolina and Virginia all have large deposits of graphite some of which are being worked; gypsum suitable for plaster manufacture is obtained in Virginia, Texas and Oklahoma and celestite the ore of strontium is found (but not so far worked) near Austin, Tex.

Clays suitable for pottery, brick and terra cotta

abound in the South and some of the finest feldspar deposits are also located here. Materials for the manufacture of Portland cement are abundantly distributed and cement and other building materials are everywhere easily available at fair prices.

Labor Markets and Transportation

After all in considering manufacturing operations, one of the most important essentials is labor. The writer has been doing considerable construction in both the North and the South during the last few years and he has found the labor problem more acute in the North than in the South. Good intelligent labor can be obtained in the South at a much lower wage than in the North. Housing conditions are much simpler and the manufacturer who is forced to establish his own colony, will appreciate the advantage of the simpler construction required for this mild climate. The cost of living is also much less in the South than in the North owing to the large supply of farm products which are near at hand and the distance to which these must be sent in order to find a high-priced market.

Another vital problem in the establishment of industries is transportation. Southern railroads have usually been considered more or less of a joke. This is the old story, however, of sending out the truth to catch a lie. The amount of railroad development which has been done in the South in the last ten years is very extensive. The Norfolk and Western Railroad is now recognized in railroad circles as second to none in the country for good management. The Southern, the Chesapeake and Ohio, the Louisville and Nashville railroads and contributing lines to these are now being brought up to a high state of efficiency.

As to markets, except when made for personal consumption, no one would care to manufacture anything if he could not sell it. No matter what the resources of a section are there must be a market place for its produce if it is to prosper. The South has a population of thirty millions who eat, drink, sleep, work and play very much as do the other seventy million Americans. Much of the output of its new chemical plants should be used at home therefore and the great central West is also more easily reached from the northern part of this section than from eastern chemical centers. The chemical industry is a very complicated and intricate structure and often the product of one branch of chemical endeavor finds its way into another. Consequently as each new chemical plant starts operation it will create a demand for another.

Summary

To sum up, it would seem that the South offers excellent opportunities for the manufacture of carbide and for the fixation of atmospheric nitrogen in the form of cyanamid owing to the possibilities of developing cheap power adjacent to inexhaustible supplies of limestone and coal; for the manufacture of aluminium and ferro-alloys in the electric furnace; for the production of phosphate compounds and fertilizers; for the manufacture of barium products including lithopone, owing to the presence of all the raw materials necessary for these in adjacent localities; for the manufacture of soda-ash and other chemicals from salt owing to the extensive brine deposits in certain southern states; for the manufacture of wood chemicals, wood pulp and cellulose substitutes because of the vast amount of timber now standing in this section; for the making of dyes from coal-tar residues; and for industries which will utilize by-product sulphuric acid.

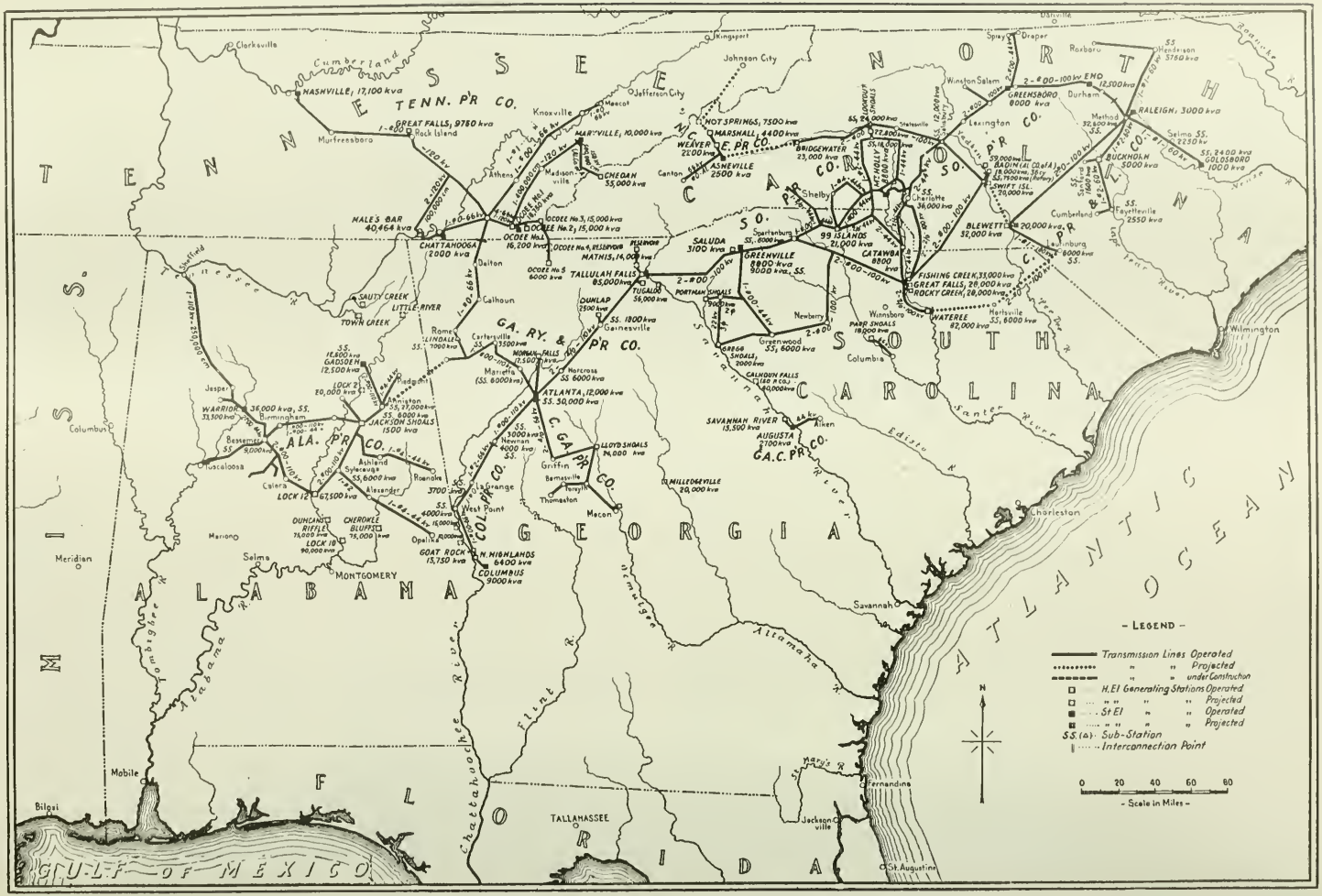
Law Building, Baltimore, Md.

New Priorities List

The United States Fuel Administration will be governed in the distribution of coal and coke by a slightly amended list of priorities recently arranged by the War Industries Boad. Not only will the industries coming under the new classification be given preferential treatment by the Fuel Administration but also in transportation by the railroads.

Aircraft: Plants engaged exclusively in manufacturing aircraft or supplies and equipment therefor.
Ammunition: Plants engaged in the manufacture of ammunition for the United States Government and the allies.
Army and Navy cantonments and camps.
Arms (small): Plants engaged in manufacturing small arms for the United States Government and the allies.
Chemicals: Plants engaged exclusively in manufacturing chemicals.
Coke plants
Domestic consumers.
Electrical equipment: Plants manufacturing same.
Electrodes: Plants producing electrodes.
Explosives: Plants manufacturing explosives.
Farm implements: Manufacturers exclusively of agricultural implements and farm operating equipment.
Feed: Plants producing feed.
Ferro-Alloys: Plants producing.
Fertilizers: Manufacturers of fertilizers.
Fire brick: Plants producing exclusively.
Food: Plants manufacturing, milling, preparing, refining, preserving, and wholesaling food for human consumption.
Food containers: Manufacturers of tin and glass containers and manufacturers exclusively of other food containers.
Gas: Gas producing plants.
Guns (large): Plants manufacturing same.
Hemp, jute, and cotton bags: Plants manufacturing exclusively hemp, jute, and cotton bags.
Insecticides: Manufacturers exclusively of insecticides and fungicides.
Iron and steel: Blast furnaces and foundries.
Laundries.
Machine tools: Plants manufacturing machine tools.
Mines.
Mines: Plants engaged exclusively in manufacturing mining tools and equipment.
Newspapers and periodicals: Plants printing and publishing exclusively newspapers and periodicals.
Oil: Refineries of both mineral and vegetable oils.
Oil production: Plants manufacturing exclusively oil well equipment.
Public institutions and buildings.
Public utilities.
Railways.
Railways: Plants manufacturing locomotives, freight cars and rails, and other plants engaged exclusively in manufacture of railway supplies.
Refrigeration: Refrigeration for food and exclusive ice-producing plants.
Seeds: Producers or wholesalers of seeds (except flower seeds).
Ships (bunker coal): Not including pleasure craft.
Ships: Plants engaged exclusively in building ships (not including pleasure craft) or in manufacturing exclusively supplies and equipment therefor.
Soap: Manufacturers of soap.
Steel: Steel plants and rolling mills.
Tanners: Tanning plants, save for patent leather.
Tanning extracts: Plants manufacturing tanning extracts.
Tin plate: Manufacturers of tin plate.
Twine (binder) and rope: Plants producing exclusively binder twine and rope.
Wire rope and rope wire: Manufacturers of same.

Non-ferrous metallurgical plants are not on the list.



INTERCONNECTED HIGH-TENSION TRANSMISSION SYSTEMS OF THE SOUTH

Interconnected Power Systems of the South

Hydro-electric Systems of Independent Companies Operating in Five States Are Connected Into One Vast Transmission System

HYDRO-ELECTRIC power is a resource that will attract to a community a line of manufacturing and chemical industries that usually seek cheap power as the prime requisite. The development of high-tension transmission systems has become common in many parts of the United States, but it was in the South that the logical and obvious thing was first done by interconnecting a number of systems with resultant advantages and economies. As shown on the map on the opposite page the Southern states can boast a high-tension line approximately 1000 miles long from Nashville, Tennessee, to Henderson, N. C. This ties together the hydro-electric systems of five companies operating in four states. In other words, all the great transmission systems of the South with the exception of that controlled by the Alabama Power Company are interconnected. It is probably only a question of time until all properties will not only be interconnected but possibly owned and controlled by a master organization.

Among the advantages which follow from the interconnection of such systems none is greater than the improvement in the diversity factor. The difference of one hour in time between Henderson, N. C., and Nashville, Tennessee, adds to the normal diversity factor of each system.

The United States Geological Survey has estimated the available power in the headwaters of the Appalachian mountains at 2,800,000 hp. The estimate for all the systems of the South is about 5,000,000 hp. The Appalachian region has an enormous rainfall with a topography that is favorable to the development of low-head power plants. The illustration at the head of this article is typical of the Southern water powers. High heads as a rule do not exist and flumes and penstocks are little used. The absence of lakes in the region makes natural storage of water impossible.

Among the power companies in the United States and Canada having yearly outputs in excess of 100,000,000 kw.-hr., there are three Southern concerns, according to data given in the *Electrical World*, March 23, 1918.

System	Peak Load, Kw	Yearly Output, Kw.-Hr.	Yearly Load Factor Per Cent.
Tennessee Power Co	85,200	547,945,475	73 41
Alabama Power Co	58,250	289,715,125	56 7
Georgia Railway & Power Co	78,200	258,607,882	

INTAKE DAM AT TALLULAH FALLS, GEORGIA RAILWAY AND POWER CO.

Alabama Power Company

The properties owned by the Alabama Power Company[1] include several sites on the Coosa River, one site on the Tallapoosa River, a site on Little River, and sites at Muscle Shoals on the Tennessee River. On these sites approximately 500,000 hp. can be developed. The hydroelectric stations of the company at present in operation are located at Lock 12 on the Coosa River, where a head of 68 ft. is available, and at Jackson Shoals, on Choccolocca Creek, where a head of 22 ft. is available. Sixty-cycle, three-phase energy is generated at 6600 volts in the Coosa River plant and 2300 volts in the Jackson Shoals plant. The company has at present in operation 180 miles of steel-tower transmission lines equipped with suspension-type insulators and 00 stranded copper cable for transmitting energy at 110,000 volts to four substations over private rights-of-way. The substations are situated at Gadsden, Anniston, Jackson Shoals and Magella near Birmingham. Substations operated at 22,000 volts are in operation at Talladega, Leeds, Lovick, Alexander City, Gadsden and Attalla. The high-tension substations

COLUMBUS POWER CO.

are of the outdoor type. It is the purpose of the company to standardize these as to size and type on 3000, 6000 and 10,000-kva. ratings. At present 45,300 kva. is installed in the four substations. The company has 25,000 kw. of available steam auxiliary apparatus, comprising a 12,500-kw. steam turbine station at Gadsden, containing two 6250-kva. units, and a 15,000-kw. steam turbine and reciprocating engine plant. With the available steam auxiliary of 25,000 kw. operating as required and furnishing approximately 7.55 per cent of the total kilowatt-hour output, 62,400 kw. of

[1]Interconnected Systems of the South, Electrical World, May 30, 1914.

YADKIN RIVER POWER COMPANY, BLEWETT FALLS, N. C. HYDRO-ELECTRIC PLANTS FROM NORTHEAST

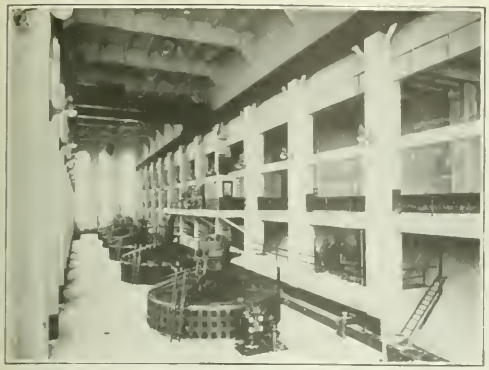
primary power at 50 per cent load-factor can be delivered as soon as another hydro-electric unit is installed. The Anniston substation is a switching station for two 110,000-volt lines which pass through it. The Jackson Shoals substation is also a switching station for three 110,000-volt circuits from the north, south and west. The Magella substation will have an ultimate rating of 67,000 kw.

Carolina Power & Light Company

The Carolina Power & Light Company, in addition to the property owned and directly operated, also controls the Yadkin River Power Company and the Asheville Power & Light Co.

The Carolina Power & Light Company operates the electric light and power service in Raleigh, Goldsboro, Henderson, Oxford, Sanford, and Jonesboro, furnishing electric light and power service for manufacturing properties in Fayetteville, Clayton, Smithfield, Selma, Franklinton, Pine Level and Cumberland. It also supplies under contract the entire requirements of the municipal electric light and power systems in Smithfield, Selma and Clayton and all the privately owned electric light and power systems in Franklinton and Pine Level. The company operates 188 miles of high-tension transmission line connecting two hydro-electric and three steam plants with distributing systems in all the communities served. The larger of the hydro-electric plants is located at Buckhorn Falls on the Cape Fear river and has an installed capacity of 3,300 horsepower. The smaller is a plant of 530 horsepower on the Neuse River near Raleigh. The company has also in reserve a modern steam plant of 5,000 horsepower ca-

GREAT FALLS PLANT OF THE SOUTHERN POWER COMPANY



90,000-HP. GENERATORS—COOSA RIVER INTERIOR VIEW LOCK NO. 12 POWER HOUSE

pacity at Raleigh, one of 950 horsepower at Goldsboro and one of 300 horsepower at Henderson. It operates nine substations with an aggregate capacity of 23,000 horsepower.

The properties of the Carolina Power & Light Company are located in the heart of the North Carolina industrial district. A large part of the electric energy sold by the company is supplied to cotton mills, cotton gins, cotton-seed oil mills, fertilizer works, veneer mills, furniture factories, machine shops, brick plants and other manufacturing establishments, and to municipalities for pumping water.

Yadkin River Development

The Yadkin River Power Company owns and operates a hydro-electric development located on the Yadkin river, at Blewett Falls, near Rockingham, North Carolina, with an initial installed capacity of 32,000 horsepower. It has in operation 184 miles of high-tension transmission lines, located on private right-of-way, and 49 miles of distributing lines, five substations, with a total capacity of 4,100 horsepower; and lighting and power systems in Rockingham, Hamlet, Wadesboro and Lilesville, North Carolina and Cheraw, South Carolina, and an electric power service in Lumberton, North Carolina. The transmission lines are connected with those of the Carolina Power & Light Company and the Southern Power Company. The power station at Blewett Falls is one of the most modern stations in the South. It is 285 feet long by 70 feet wide, three stories in height, and is built of steel and brick with concrete foundations, floor and roof. The dam is of solid concrete construction. It has a total length of 1,470 feet and a maximum height of 50 feet. The dam has created a reservoir eight miles in length with a total area of 2,500 acres. The station was placed in regular operation in June, 1912.

Like the properties of the Carolina Power & Light Company, those of the Yadkin River Power Company are located in the Carolina cotton-mill district, and a large part of the electric energy sold by it is supplied to cotton mills, cotton gins and cotton-seed oil mills. It also supplies power to numerous other industrial plants, such as fertilizer works, veneer mills, furniture factories, brick plants and railroad shops, and to municipalities for pumping water.

Columbus Power Company

The Columbus Power Company[2] has three hydro-electric developments on the Chattahoochee River, two at Columbus having an aggregate rating of 9000 kva. and one at Goat Rock, 15 miles north of Columbus, having 13,750 kva. installed, making the total available 22,750 kva. The City Mills development at Columbus comprises five generators with an aggregate rating of 1000 kw., the head being 10 ft. The North Highlands development has six generators, with an aggregate rating of 6900 kw., and waterwheels operating under a head of 42 ft. The Goat Rock development, where a head of 72 ft. is available, has three generators, two of which are rated at 3750 kw. and the other at 5000 kw. Three-phase, sixty-cycle energy is generated at 5500 volts and 11,000 volts. Two 4000-kw. transformers step up the potential to 66,000 volts for transmission. A 11,000-volt line on wooden poles with pin-type insulators connects the Columbus and Goat Rock properties, and a 60-mile steel-tower line equipped with suspension-type insulators and operating at 66,000 volts extends from Goat Rock at Newnan. There is

DUNLAP PLANT, GEORGIA RAILWAY AND POWER CO.

ROCKY CREEK PLANT OF THE SOUTHERN POWER COMPANY

LOCK 12 HYDRO-ELECTRIC PLANT—DOWN-STREAM VIEW

18 miles of wooden-pole line operating at 11,000 volt connecting Newnan and Hogansville. Four main substations are connected to the system, one at Columbus rated at 1600 kw., one at West Point rated at 1875 kw., one at La Grange rated at 1875 kw. and the fourth at Newnan rated at 4000 kw. The system operates continuously on a 40 per cent load-factor basis, and auxiliary steam generating apparatus of the capacity of of 3000-kw. turbo-generators is available. Provision is made for the transfer of 3000 kw. between the Columbus Power Company's system and the system of the Georgia Railway & Power Co.

Georgia Railway and Power Co.

The present coal supply conditions emphasize the importance of existing water-power generating plants and the vital need of additional developments.

The 100,000-hp. plant of the Georgia Railway and Power Company at Tallulah Falls was barely finished when the rapid increase in the demand for hydro-electric power forced the company to undertake the construction of additional water-power developments, which, when completed, will nearly double the present capacity of its existing water-power plants.

The growth of the business in the past six years is shown in the following table of yearly outputs in kilowatt-hours:

1912	68,400,642	1915	179,976,596
1913	80,763,025	1916	211,872,638
1914	145,684,803	1917	258,607,802

This shows an increase in that period of nearly 300 per cent or, in other words, the volume of business almost doubled twice.

The water power furnished by the company to its customers in 1917 would have required approximately 475,000 tons of coal if generated by them by steam. The additional water power which it is estimated will be generated at the new plants now under construction, and which has already been largely sold, will take the place of and save approximately 400,000 tons of coal annually—a total combined saving of approximately 875,000 tons of coal per annum.

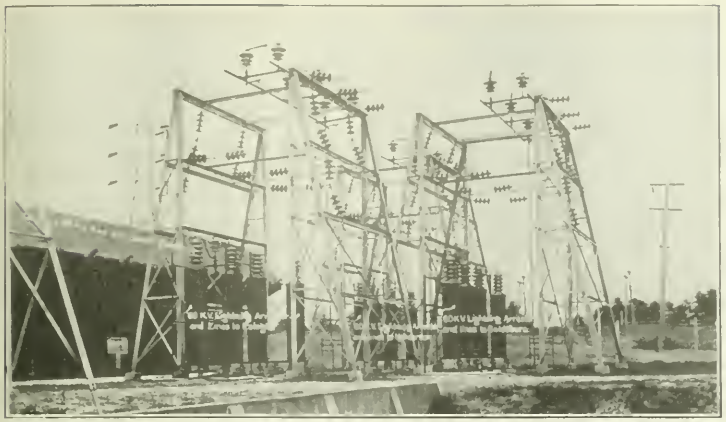
The new developments now being constructed are:

Burton Storage Reservoir

(To be in service by the end of year 1918)

The Burton storage reservoir is three miles north of the present Mathis storage reservoir, and will flood approximately 3000 acres of land. It requires the construction of a dam 700 feet long and 100 feet high of cyclopean masonry. The reservoir will store approximately five billion cubic feet of water. The water contained in this reservoir, exclusive of the average flow of the river, will produce at the Tallulah Falls and Tugaloo generating plants 65,000,000 kilowatt-hours and will increase the annual capacity of those plants to that extent. This reservoir will also make possible the equalization of the river flow, or in other words, the even distribution of all available rainfall run-off from

LOCK 12 HYDRO-ELECTRIC PLANT—UP-STREAM VIEW



METHOD, (N. C.) OUTDOOR SUBSTATION LOOKING NORTH. CAROLINA POWER AND LIGHT COMPANY

its contributary water shed throughout every month in the year, the stored water being drawn out for use in the dry months and replaced in the wet season. The water that can be stored in this reservoir is equivalent to the available energy in 130,000 tons of coal.

Tugaloo Development

The Tugaloo development is situated about two miles below the present Tallulah Falls power house on the Tugaloo river where the Tallulah and the Chattooga rivers come together and form the Tugaloo. The water available at this point for power purposes come from both the Tallulah and the Chattooga rivers. The average flow of the river, including the effect of the Mathis storage reservoir, it is estimated will produce at this plant approximately 120,000,000 kilowatt-hours. It will require only one and one-half miles of transmission line to connect this development with the present Tallulah Falls transmission lines. The Tugaloo dam of cyclopean masonry is 800 feet long and 140 feet high. The Tugaloo plant will develop approximately 65,000 hp., and it is estimated that two years time will be necessary in which to complete it.

Sixth Unit

(To be in service during the summer of 1918)

The Tallulah Falls power plant was constructed and designed for six units of 12,000 kilowatts or about 17,000 horsepower each. Five units are now installed. The sixth unit has been ordered and will be ready for service sometime during the summer of 1918.

Contracts were let for all the required equipment for the three developments during the summer of 1917 and construction is now actively under way.

The estimated total cost of this construction is $5,000,000. The necessary financing to carry on the work was completed in June, 1917. The company was fortunate in this respect because the war has since brought such changed financial conditions that the necessary capital could not be secured at the present time and this has been continuously true since the financial arrangements were concluded.

The Georgia Railway and Power Company upon completion of the plants now under construction will have water-power plants of approximately 200,000 horsepower developed and in service.

The company controls approximately 300,000 undeveloped horsepower in addition, or a total developed and undeveloped of approximately 500,000 horsepower.

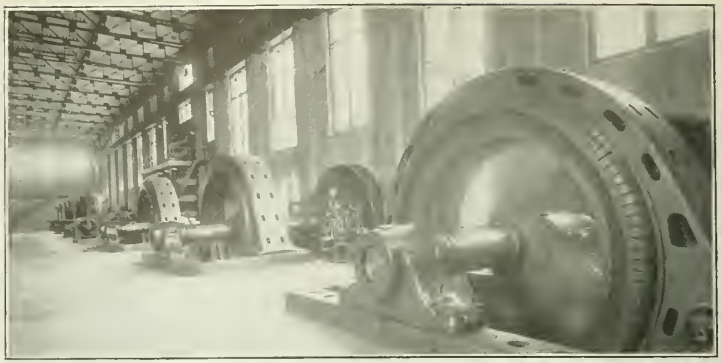
A very large part of the power generated by the company is being used by enterprises making war materials or supplies necessary to the successful prosecution of the war. This shows how doubly vital it is in war times that money for such developments should be available.

It also points the lesson that many of us appreciated years ago, viz., the necessity of a broad and generous policy on the part of the Government in the development of the water powers of the nation.

THE TALLASSEE POWER COMPANY, YADKIN RIVER, BADIN, N. C.

Water power should be provided to meet the increasing demand due to the war. But war conditions have made money unobtainable through the usual banking channels. From now on and as long as present conditions exist such developments cannot be made unless the national government will furnish the needed capital.

The French government realized early in the war the vital need of largely increasing the available power for industrial purposes from other sources than coal and is now constructing water-power developments in Southern France on a large scale under the direction of an American engineer.



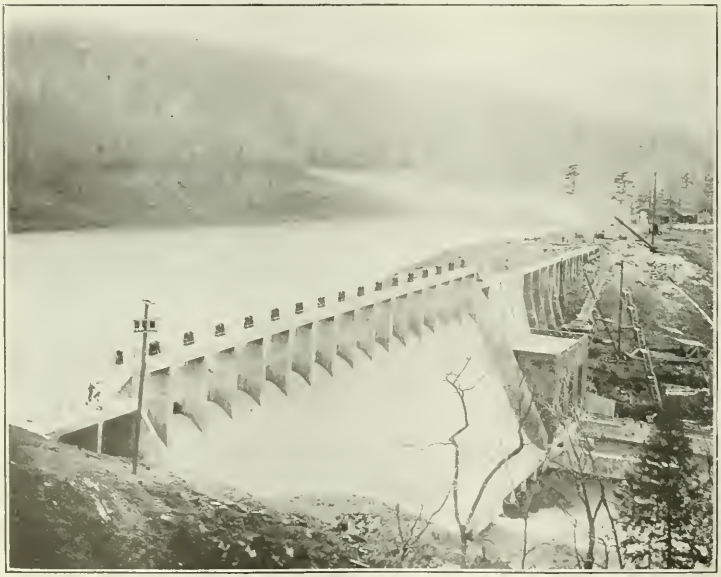
YADKIN RIVER POWER COMPANY. 3-4500 KVA, 3-6000 KVA, 4000 VOLT, 60 CYCLE G. E. GENERATORS

Coal Saved by Hydro-electric Development

The power actually furnished by the Georgia Railway and Power Company, in 1917, if generated by its customers by steam, would have required 11,875 cars of coal of 40 tons capacity each, and the estimated power which will annually be generated by the plants now being constructed, will be the equivalent of 10,000 cars of coal of 40 tons capacity each additional, or a combined saving in coal consumption per annum of 21,875 cars of coal of 40 tons capacity each. If the remaining 300,000 horsepower of undeveloped water power controlled by the company could be developed and put to work, the saving would be two and one-half times as great or a total of 54,687 cars of coal of 40 tons capacity each, or 2,187,480 tons of coal conserved with all its collateral economies.

If capital were now available for the construction of the necessary generating plants sufficient to utilize the undeveloped water power controlled by the Georgia Railway and Power Company, and the national government would bring about the electrification of the steam railroads, all the important railroad mileage in Georgia would be operated by electric power generated by the Georgia Railway and Power Company. The operating expenses of the railroads themselves would be materially reduced, their service much improved, and in addition the coal now consumed by them conserved, and the present regular business of the company supplied and developed as at present.

Our armies at the front will be of no use unless supplied with food and equipment. This necessitates the development and speeding up of most industries to the top notch of production. Business essential to the war must produce as never before to supply our armies at the front, our industrial armies at home, and in addition to furnish taxable values to foot the bills. To this end the efforts of a vast industrial army at home, co-ordinated to supply the needs of the army at the front, are as necessary as the fighting men themselves. Present conditions emphasize the value of water power as never before. Is not this situation deserving of prompt attention by the national government? The President of the United States thinks so, because he called the attention of Congress specifically to the development of water powers in one of his most recent messages.



MATHIS DAM, GEORGIA RAILWAY AND POWER CO.

YADKIN RIVER POWER COMPANY, BLEWETT FALLS, DAM AND POND

Southern Power Company

The Southern Power Company[3] is connected to the Carolina Power & Light Company at a point between Durham and Raleigh, N. C., as indicated on the map, and with the Georgia Railway & Power Company at Tallulah Falls. The location and maximum ratings of the company's various stations are given in the accompanying table.

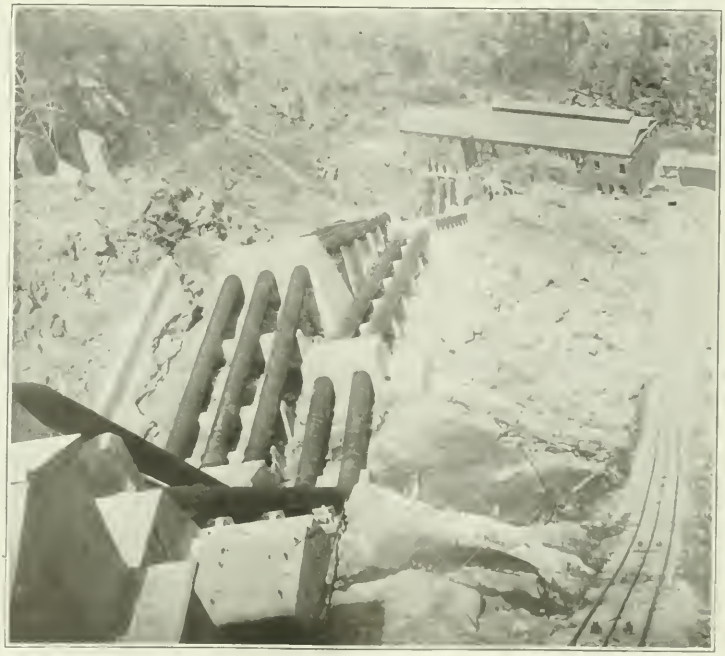
DATA ON SOUTHERN POWER COMPANY'S STATIONS

Location	Maximum Rating	Head, Ft.
Great Falls, S. C.	24,000 Kw.	72
Rocky Creek, S. C.	24,000 Kw	63
Ninety-nine Islands, S. C.	18,000 Kw	72
Catawba, S. C.	6,600 Kw.	25
Lookout Shoals, N. C. (under construction)	24,000 Kw.	76
Greenville, S. C. (steam)	8,000 Kw.-a.	
Greensboro, N. C. (steam)	8,000 Kv.-a.	
Mount Holly, N. C. (steam)	8,000 Kv.-a.	

Electricity is generated at 2200, 6600 and 11,000 volts, three-phase, sixty-cycle, there being one 8000-kva, 2300-volt and two 8000-kva, 11,000-volt steam-driven generators, twenty-two 3000-kva, 3000-volt generators, three 7800-kva, 6600-volt generators, four 900-kva, and 750-kva, 11,000-volt generators. The last thirty-three units are of the waterwheel type. There are also connected to the system sixty-five high-voltage transformers having an aggregate rating of 169,400 kva. The lines of the company cover a territory of 300 miles in a northeasterly and southwesterly direction and 100 miles in a northwesterly and southeasterly direction. The first transmission system of the company is designed for 11,000 volts. With the expansion of the company and its activities, a 44,000-volt transmission system was built, and all of the recent transmission lines erected by the company have been designed for 100,000 volts. All lines are looped in together, and the 11,000-volt and 100,000-volt systems are tied together with tie-in transformers. Aluminum and copper are both used for conductors, the size ranging from No. 4 solid copper to No. 000 stranded. By far the greatest amount of the lines are of No. 00 copper stranded and No. 00 equivalent aluminum stranded. This is run on both steel towers and wooden poles with pin-type and suspension-type insulators, depending upon the voltage. There are 103 substations connected to the system, containing 352 transformers with an aggregate rating of 241,162 kva.

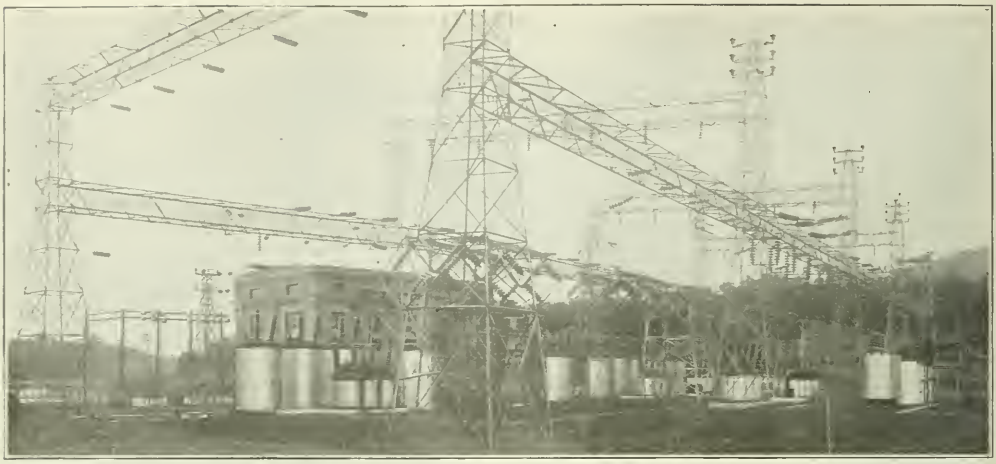
The circuits of the Southern Power Company are connected on the north with those of the Carolina Power & Light Company with two 100,000-volt lines. The amount of power that can be transferred is limited only by the carrying capacity of these lines, as no transformers are required in order to effect this connection. On the south the Southern Power Company's system is connected with that of the Georgia Railway & Power Company at Tallulah Falls, with two 100,000-volt lines, and the power which can be transferred between the two companies at this point is limited only by the carrying capacity of the lines.

It should be pointed out that the rating of the hydroelectric stations of the Southern Power Company is based upon the continuous rating for the continuous amount of twelve-hour power which the station can generate for eight months in the year. The company maintains three 8000-kva. turbo-generator steam plants



PENSTOCKS CONNECTING FOREBAY WITH POWER HOUSE, GEORGIA RAILWAY AND POWER CO.

[3]Ibid.



SUBSTATION—ALABAMA POWER COMPANY, COOSA RIVER HYDROELECTRIC PLANT

for emergency and supplementary service. The fires under the boilers are banked, and all three stations can be got under way to feed energy to the lines within fifteen minutes.

Tennessee Power Co.

The present hydro-electric stations owned and operated by the Tennessee Power Company are as follows:

Ocoee No. 1, located in Polk County at Parksville, Tennessee, on the Ocoee river, approximately 50 miles from Chattanooga. The equipment in this plant consists of five horizontal direct-connected water-wheel-driven generators, each one having a capacity of 3750 kilowatts, the total station capacity being 18,750 kilowatts. The dam at this plant backs up the Ocoee River, forming a lake approximately eight miles long. Sufficient water is impounded to operate the station over a period of two or three weeks during reduced stream flow.

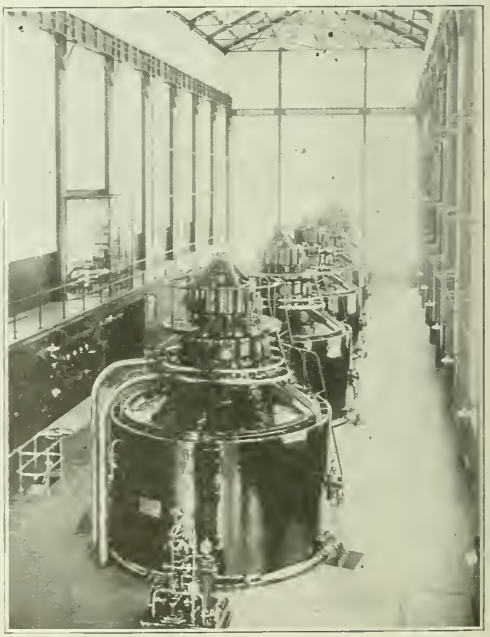
Ocoee No. 2, located in Polk County on the Ocoee river, about ten miles east of Parksville. This plant is equipped with two horizontal water-wheel-driven generators, each having a capacity of 7500 kilowatts, the total capacity of the station being 15,000 kilowatts. This plant uses the stream flow from the Ocoee river, which is diverted by means of a low dam, five miles above the power station, from which the water is conveyed by means of a flume to a forebay above the power house. The operating head at this plant is 255 feet.

Great Falls Station, located at the northwest corner of Warren County, about half way between Nashville and Chattanooga. This plant uses the flow of the Caney Fork and Collins rivers. A low concrete dam is located just below the confluence of the two rivers which diverts the two streams which are conveyed to the water wheel by means of a tunnel and penstock. The plant is equipped with one vertical water-wheel-driven generator, the capacity being 9750 kilowatts.

Hales Bar, located on the Tennessee river about 20 miles west of Chattanooga. This plant is equipped with fourteen 3000-kilowatt vertical turbines, the total capacity of the station being 42,000 kilowatts. The concrete dam across the river at the power house site backs up the water and makes the river navigable to Chattanooga. The spillway is 1200 feet long. The dam is provided with a boat-lock which is operated by the government.

The combined capacity of the present hydro-electric stations is 85,000 kilowatts.

Proposed hydro-electric developments: Additional developments have been considered, and rights ob-



GENERATORS, TALLULAH FALLS POWER HOUSE, GEORGIA RAILWAY AND POWER CO.

TALLULAH FALLS POWER HOUSE, GEORGIA RAILWAY AND POWER CO.

tained for three more stations on the Ocoee river, to be known as Ocoee No. 3, Ocoee No. 4 and Ocoee No. 5. The additional capacity from these three stations will be in the neighborhood of 35,000 kilowatts.

Steam Plants: The Tennessee Power Company has an arrangement with the Chattanooga Railway and Light Company, the Nashville Railway and Light Company and the Knoxville Railway and Light Company whereby the steam plants at these three cities may be operated at the direction of the Power Company to supplement the output from the hydro plants during low water. The capacities of the steam stations are as follows:

	Kilowatts
Chattanooga	5,000
Nashville	15,000
Knoxville	4,000
Total	24,000

The Tennessee Power generates the electrical energy used in Chattanooga, Nashville, Knoxville and a large number of the small cities in eastern Tennessee. In addition it supplies power to the Aluminum Company of America at Maryville, Tennessee, 16 miles south of Knoxville, and also to the American Zinc Company at Mascot, Tennessee, 15 miles northeast of Knoxville. The total transmission line mileage is aproximately 600 miles.

The rates for electrical energy are in accordance with the following tabulation:

"A fixed charge of $1.25 per month per kilowatt of maximum demand based on the highest fifteen minute demand during the month, but in no event shall the fixed charge be less than 60% of the total kilowatt capacity contracted for.

"In addition to the above demand charge the following kilowatt hour charge for electrical energy consumed during the month:

	Kilowatt-Hours
4c. per kw.-hr. for the first	500
2c. per kw.-hr. for the next	1,000
1½c. per kw.-hr. for the next	1,500
1c. per kw.-hr. for the next	17,000
0.7c. per kw.-hr. for all over	20,000

"A discount of five (5%) per cent will be allowed upon all bills paid within ten (10) days from their date."

Dyestuff Association Officially Organized.—The Board of Governers of the American Dyestuff Manufacturers' Association met on April 4, at the office of its counsel, Benjamin M. Kaye, 149 Broadway, to elect officers, execute the certificate of incorporation issued by the Secretary of State at Albany, and adopt the constitution and bylaws. The officers elected were: President, Morris R. Poucher of E. I du Pont de Nemours & Co., Wilmington, Del.; First Vice-President, L. A. Ault of Ault & Wilborg, Cincinnati, Ohio; Second Vice-President, Frank Hemingway of Frank Hemingway, Inc., New York; Secretary, C. Cyril Bennett, manager of the Color Trade Journal, New York, and Treasurer, Charles Jenkinson of the National City Bank, New York. Within a short time the association will start an intensive drive in propoganda work in order to acquaint the American public with the enormous strides made in the color industry in this country since the start of the European war. One of the undisguised objects of the new association is to prevent German aggression in the dyestuffs industry in this country after the war. Membership in the organization is open to American manufacturers of dyes and intermediates.

Chemical Trade Specifications.—A definite need which is becoming apparent as our chemical industry expands, is a publication of trade specifications and standards covering those chemical products which are general articles of commerce. This need will become more insistent as new and inexperienced men engage in the buying and selling of chemicals. Their unfamiliarity with trade terms and customs will be fruitful of disagreements unless recognized standards can be freely consulted and made the basis of negotiations. In the hope and expectation of meeting this need Dr. Wallace P. Cohoe of New York, with the cooperation of METALLURGICAL AND CHEMICAL ENGINEERING, has begun the collection of data that will embody a general statement of current trade standards, and which will be published in book form by the McGraw-Hill Book Co. as soon as the compilation can be completed.

Electric Furnaces Discussed by Faraday Society

AT a meeting of the Faraday Society on Thursday, Feb. 14, at Manchester, England, a general discussion took place on electric furnaces. The discussion was presided over by Professor C. A. EDWARDS of the University, Manchester.

The Chairman, in introducing the subject, gave a short account of the history of electric smelting since Siemens in 1878 patented his first small coke electric furnace. In 1904 there were only four electric furnaces in Europe and America; in 1913 there were 114. Development since the war had been phenomenal.

Mr. H. ETCHELLS read a paper on *"Applications of Electric Furnace Methods to Industrial Processes."*

The author referred to the growth of electric furnace industries during the war, which was due not only to the greater output demanded, but to a certain extent because the electric furnace enabled us to use raw materials which were formerly considered inferior for the quality of product desired.

In dividing electric furnaces under the three headings *Induction*, *Resistance*, and *Arc* types, the author considered that only the latter two types may be looked to for future extensive development. A plea was made for the greater development of the resistance furnace, which from the electric load viewpoint was ideal, giving high load factor, high power factor, and very slight fluctuation. The Bailey furnaces were mentioned as the only furnaces of this type which had hitherto attained an industrial development in large units.

The greatest development of electric furnaces, it was pointed out, had taken place in connection with the steel industry, and especially in regard to the production of special high quality steel castings. In the author's opinion, the electric furnace is not fulfilling its highest function in the foundry when used for simply melting steel scrap to turn out an unrefined product on an acid lining.

The success attained by the Greaves-Etchells furnace in high-speed steels was specially indicated, some Sheffield firms having dispensed with the crucible process and adopted the electric process whole-heartedly.

The unsatisfactory performance of refractory lining materials at present marketed was commented upon, and the author stated it as his belief that satisfactory linings would not be available until electrically fused refractories were put on the market.

Mr. J. BIBBY read a paper on *"Electric Steel Refining Furnaces."* He said the development of the electric furnace for steel making is almost certain to take place in the direction of large furnaces. As furnaces get larger new conditions appear, which require consideration in the design, but economies can be effected in consumption of current, refractory materials and labor. On small furnaces, up to 5 tons' capacity, two electrodes are suffifficient, but on the larger furnaces it is advisable not to concentrate the heating zone in two places, but to distribute it by having four electrodes over a circular bath. Further, on large furnaces large currents are required, and up to the present we only have electrodes which will take currents of, say, 10,000 amp., so that where more than 20,000 amp. are required, more than two electrodes are required for this reason. In the use of four upper electrodes we are confronted with an electrical problem. It was explained in the paper that whatever system is adopted it must be such that when equal currents are flowing through each of the arcs, then equal currents must be taken from each of the three high-tension mains, and each of these three primary currents must be practically in phase with its voltage in order to secure a higher power factor. Further, for metallurgical reasons it is considered desirable that a certain amount of current should flow vertically through the hearth to a fifth fixed electrode beneath it. We therefore require some system which will impress an equal voltage between each upper electrode and the hearth electrode, so that when equally adjusted equal currents, and therefore four equal heating zones, will be obtained.

The condition is met if we can obtain on the furnace side of the transformers four equal phases, one for each electrode, and a common return to a neutral electrode beneath the hearth. In short, we require a four-phase, five-wire system. This can be obtained by simply having two sets of two phases working in parallel, but this system has serious electrical objections. The problem has been satisfactorily solved by the Electro-Metals four-phase arrangement, which consists of three single-phase transformers. Two of these transformers have their terminals connected separately to the four upper electrodes. A tapping is taken from the middle of the third or Teaser transformer to the hearth electrode, and the terminals of the Teaser transformer are connected to intermediate tappings on the main transformers. A closed system is thus obtained when arcs are struck between the four upper electrodes and the bath of metal. This system gives an equal voltage in each of the arcs and therefore equal heating zones, and also when the electrodes are regulated for equal currents, then equal currents are taken from the three primary mains. The average power factor of the system on a non-inductive load is unity. Further advantages of the system are that when the furnace is under poor regulation the primary currents remain tolerably balanced with a high power factor.

A paper on *"Electric Furnace Control"* was presented by Mr. A. P. M. FLEMING and Mr. F. E. HILL.

The methods of control are classified as follows:

I. By Variation of Voltage

(1) Alteration of the ratio of the main transformer by cutting out a portion of the primary winding.

(2) Alteration of the ratio of the main transformer by an auxiliary winding which can be connected up in series with or in opposition to the main winding.

(3) Use of a primary booster transformer to vary the secondary voltage by altering the pressure supplied to the primary.

(4) Use of a secondary booster transformer, the secondary of which is in series with the main secondary, the booster primary being in parallel with the main primary.

(5) Control by means of a motor-generator; a method rarely used.

II. By Variation of Current

Control by this method is accomplished by raising or lowering the electrodes. It may be employed as an auxiliary method to any of those previously described. Examples of both hand regulation and automatic regulation are given in the paper.

Synopsis of Recent Metallurgical and Chemical Literature

Comparison of High-Temperature Scales. — E. P. HYDE and W. E. FORSYTHE of the Nela Research Laboratory presented a paper at the Rochester meeting of the American Physical Society giving the final results of a study on the above subject, and which present a very clear idea of the relative accuracy with which carefully made temperature determinations can be compared. The intercomparison of the temperature scales of the Bureau of Standards, the Physical Laboratory of the University of Wisconsin, the Research Laboratory of the General Electric Company at Schenectady, and the Nela Research Laboratory was carried out through measurements made on several tungsten-filament lamps, the exact point at which it was desired to have the temperature measured being indicated either by a pointer, a notch on the supporting lead, or a small notch on the filament itself. High-temperature scales are for the most part based on the temperatures of standard melting points for the most part obtained inside a standard black-body furnace and extended beyond these points by means of radiation laws. All the above laboratories (except the University of Wisconsin, which used palladium at 1822 deg. K.) base their temperature scale on the melting point of gold (1336 deg. K.) and extrapolate by means of Wien's equation using for C_2 14350 $\mu \times$ deg. There are three sources of error: (1) in obtaining the temperature of the melting point, (2) in the blackness of the furnace used, and (3) in the extrapolation, and the combination might well lead to large uncertainties in the final result. The results in deg. K. are given in the following table, in part, reduced to the melting point of palladium. As the red-glass screen used in the different laboratories varied somewhat, it was necessary to reduce the temperatures to the same wave length (0.665μ). Holborn-Kurlbaum pyrometers were used.

Lamp No.	T-16-B	T-30-C	T-17-C	T-18-B
Nela	1618	2756		
Schenectady	1613	2752		
Nela	1617	2752		
Bureau Standards	1619	2762		
Nela	1614	2752	2499	2105
Wisconsin			2511	2121
Nela			2497	2107

Furnace Control by Optical Pyrometers.—The making of optical glass is strictly dependent upon the furnace temperatures, as noted by C. N. FENNER of the Geophysical Laboratory (The Physical Review, Vol. XI, p 141.) If the temperature of melting and fining is a little lower than supposed the resulting glass will be full of bubbles, or even milky. On the other hand, too high temperatures will corrode even the best melting pots, contributing stones to the melt, sometimes corroding through. These important considerations limit the operations to a temperature range between 1300 and 1400 deg. C. The furnaces in the Bausch and Lomb plant had been equipped with platinum thermocouples, but rapid contamination by furnace gases caused unsatisfactory service. A Morse instrument has been substituted with excellent results, the furnace men being easily educated to its use. Previously to making the change it was found that the calibration chart furnished by the makers was correct at all points to within a very few degrees or the limit of error. A more important test was whether the furnace walls radiated as a black body. This was investigated by means of a platinum thermocouple contained in a Marquardt porcelain tube fixed in the end of a water-cooled iron pipe extension, through which the lead wires extended. By using this simultaneously with the optical pyrometer, the temperatures of the walls as observed by optical and thermo-electric were almost identical. At temperatures lower than 1300, however, the optical readings were high, owing to the error caused by the reflection of the flames from the glazed walls.

Ferrous Metallurgy in Canada.—DR. ALFRED STANSFIELD, in a paper on "Recent Advances in Canadian Metallurgy" before the March meeting of the Canadian Society of Civil Engineers notes that a recent study of the Lake St. John (Quebec) District has caused him to modify his opinion expressed after a study of the Swedish industry just prior to the war that it would not be profitable to produce electric pig iron in Canada, since at Lake St. John a high-grade white iron containing titanium appears to be a desirable possibility. The Canadian production of electric steel has increased from 61 tons in 1914 to approximately 50,000 tons in 1917, mostly as shell billets from steel scrap. Several furnaces are in operation in and about Montreal, the Munitions Board has built ten 6-ton furnaces at Toronto, and the Armstrong Whitworth Company has built a plant for the production of electric tool steel at Longueuil. While the furnace at Belleville has made much good steel from titaniferous ore, it has been found cheaper to use scrap. This furnace and another at Orilla has recently been fully occupied with the production of ferro-molybdenum. Before the war from eight to ten thousand tons of ferro alloys, mostly ferro-silicon, were made annually at Welland by the Electro-Metals, Ltd. This alloy is now made also at Shawinigan. In 1916 the production of ferro alloys had increased to 28,600 tons, valued at $1,777,000, and included a large tonnage of ferro-phosphorus made at Buckingham, P. Q., by the Electric Reduction Company.

The Electrodeposition of Zinc.—In a paper to be presented at the fall meeting of the American Institute of Mining Engineers, C. A. HANSEN, of the General Electric Company, gives some important information on the proper practice in electrolytic zinc. He postulates two major reactions in the cell: first, zinc deposition at the cathode according to Faraday's constant, and second, corrosion of this zinc by the solutions according to the surface exposed and the chemical activity of the solution as mainly determined by its acidity. He also discusses the meager data on the effect of temperature on the deposition, showing a reduced current efficiency in pure solutions at higher temperatures, and he shows that its bad effect may be obviated by (a) flushing out the unsatisfactory solution, (b) cutting down the cell current, reducing the acid concentration and therefore the corrosion, as well as the energy input, and (c) using glue, lanolin, and other organic reagents whose effect,

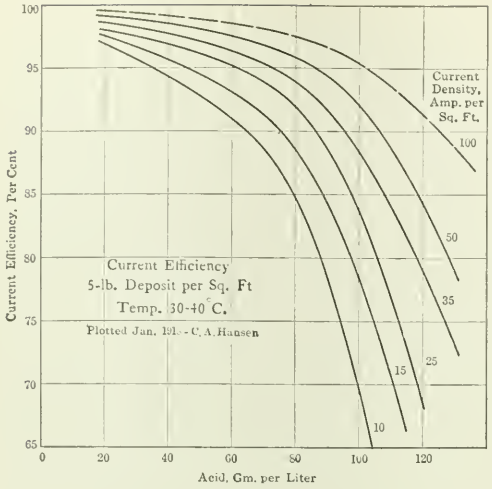


FIG. 1.

though beneficial, is cursory. According to the author's postulates, the difference between 100 per cent current efficiency and the actual is a measure of the corrosion rate. Since the latter increases with the current density (high current densities yield rougher deposits, particularly with low acid concentrations), this conclusion agrees qualitatively with facts. Values from the curves, Figure 1, do not agree as well with observed results as expected, and a second variable is thought to be the lack of zinc which exists in high acid solutions. The voltage data of Figure 2 were determined in a special cell so constructed as to avoid the errors of small cells, and include contact and other losses. Direct current data for the electrolysis

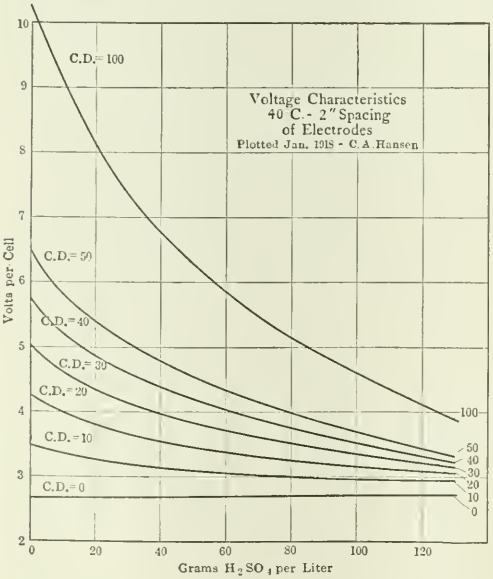


FIG. 2.

of pure zinc sulphate solutions should be multiplied by the factor 1.145 or 1.21 depending upon the electrical conversion apparatus in use. The cost of the cell room is almost inversely proportional to the current density. High leach-tank temperatures which are desirable are largely had by low current efficiency, which is undesirable.

Non-cumulative impurities in the electrolyte are copper, cadmium, arsenic, antimony, iron, manganese, silica and alumina. Copper and cadmium are precipitated with zinc, and will come down in the early cells

Cu or Cd, milligrams per liter	0	5	10
Acid, 30 gm. per liter	99	93	90
Acid, 60 gm. per liter	96	87	81
Acid, 90 gm. per liter	93	76	65

of a cascade, in which the current efficiency will no longer correspond to that expected for pure solutions.

Arsenic and antimony are not precipitated, but remain in the effluent. They are less dangerous in manganese-free electrolytes; with manganese a variation from 0.0003 to 0.001 gram antimony per liter made the difference between excellent and impossible cell-room practice.

The behavior of iron is less consistent, but it evidently serves no good purpose. Manganese by itself exerts no harm. The sulphate is oxidized in part to permanganic acid at the anode, reacting with the sul-

Acid, Grams per Liter	Arsenic, Milligrams per Liter			Antimony, Milligrams per Liter		
	0	5	10	0	5	10
30	99	94	90	99	91	84
60	96	83	77	96	80	65
90	93	66	50	93	63	35

phate and throwing out manganese dioxide at the surface of the anode itself. This dioxide adheres with low acid concentration, with higher it drops as a slime always containing substantially the same amount of lead peroxide.

Some cumulative impurities are unimportant; such are the alkali metals and magnesium. Others, such as nickel, cobalt, vanadium and possibly uranium affect the cells when in such small amounts that chemical analysis can hardly detect them. The behavior of the cell itself is thus the surest check on the thoroughness of the purification. The effect of cobalt is shown by the following table:

Co, Milligrams per Liter	0	5	10	15	20
Acid, 30 gm. per liter	99	96	93	91	87
Acid, 60 gm. per liter	96	90	85	77	64
Acid, 90 gm. per liter	93	80	70	55	30

Pure solutions invariably yield excellent deposits, wholly without blemish on the starting sheet side. Pinholes are almost always found when impurities in quantity of tenths of milligrams per liter are present. If serious quantities are present, a good deposit may form for some hours, and then start corroding at such a rate that it entirely disappears, only to be redeposited later. It is the realization that thorough purification is a necessity which has made the process commercial. In spite of the effort spent on synthetic solutions, no inorganic addition agent has been found which improves the power characteristics of the cell, or affects the product other than forming a slightly smoother deposit.

Temperature Sensitive Paints.—In the *General Electric Review* for February, W. S. ANDREWS gives some condensed data on temperature sensitive paints. He says this term has been applied to chemical compounds that are subject to color changes at a comparatively small rise in temperature. These paints are occasionally used for indicating a dangerous rise in the temperature of machine bearings, electric generators and other apparatus where excessive heating has to be avoided. The two compounds described are easy to make and reliable in operation. The double iodide of mercury and copper is normally red but turns black at about 87 deg. C., becoming red again when the temperature falls. To prepare it make separate solutions of copper sulphate and potassium iodide in distilled water. Add the latter to the former with constant stirring until the precipitate which is first formed is re-dissolved. Then add a strong solution of mercuric chloride (corrosive sublimate) and the red double iodide of mercury and copper will be precipitated. Wash and dry this precipitate on filter paper. The red powder may be mixed with a weak solution of gum arabic in water and used as a paint. The double iodide of mercury and silver is normally of a light primrose yellow, but turns to a dark orange or brick red at about 45 deg. C. It becomes yellow again on cooling—and it may be heated and cooled an unlimited number of times without losing its curious property, providing it is not overheated. To prepare it make separate solutions of silver nitrate and potassium iodide in distilled water. Add the latter to the former with constant stirring until the original precipitate is dissolved. Then add a strong solution of mercuric chloride (corrosive sublimate), which will produce a precipitate of the double iodide of mercury and silver of a bright yellow color. Wash and dry the precipitate on filter paper. It can be used as a paint by mixing with a weak solution of gum arabic in water.

Recent Metallurgical and Chemical Patents

Wood Distillation

Distilling Pyroligneous Acid.—H. O. V. BERGSTRÖM, of Stockholm, Sweden, patents a process of distilling pyroligneous acid under pressure. In the dry distillation of wood or other substance containing cellulose, so-called pyroligneous acid is obtained which principally contains water, acetic acid, wood spirit and tar or tarry constituents dissolved in the pyroligneous acid. The acetic acid is generally recovered in the form of acetate of lime and in order to obtain an acetate containing a high percentage of Ca (OCOCH), the pyroligneous acid is preferably distilled and the distillate is saturated with lime and evaporated. The present invention refers to a method of distilling pyroligneous acid which utilizes the distillation vapors. The charactertistic feature consists in executing the whole process under superatmospheric pressure in the system of apparatus. Consequently, the distillation of the pyroligneous acid is performed under an increased pressure, say 2–4 atmospheres, in the distillation boiler, the vapors formed during the distillation are led also under an increased pressure into lime white or other substance adapted for binding the acid constituents of the same, and the resulting vapors are also held under an increased pressure when utilized for heating purposes, for example for distilling pyroligneous acid, for depriving the same of spirit, for drying the acetate obtained, etc. Another feature of the invention consists in passing the vapors from the distillation of the pyroligneous acid through liquid pyroligneous acid (crude or deprived of spirit) before being led into the lime white or other substance adapted for binding the acid constituents of the same. By this means the tar or tarry constituents are removed from the vapors before they are led into the lime white and a purer acetate is formed.

Another feature of the invention consists in that the vapors, washed with pyroligneous acid or not, instead of being directly led into lime white or the like, are led into a heating element surrounded by acetate solution or other liquid which is to be concentrated. The vapors are condensed in said heating element and the condensate is then saturated with lime or other base for forming acetate solution. In passing through the heating element the vapors give off their heat to the solution, or liquid surrounding the same, the solution being thereby brought to boiling and is, thus, concentrated. The vapors escaping from the boiling solution or liquid may still be maintained under an increased pressure and be utilized for heating purposes as stated above. Another feature consists in using acetate solution instead of water for slaking the lime in order to obtain the lime white necessary for neutralizing the acid constituents of the vapors either in the state of vapors or after having been condensed. (1,261,344 Apr. 2, 1918.)

Dyes and Intermediates

Vat Dyestuffs.—M. P. SCHMIDT, of Biebrich-on-the-Rhine, Germany, patents a process for the manufacture of vat dyestuffs of the carbazole naphtho quinone series. He has found that the carbazole-naphtho-quinones derived from alpha- or beta- naphthylamine still present a similar capacity of condensation as the simple quinones themselves. They give valuable vat dyestuffs of a brown to black tint with the usual compounds containing reactive hydrogen-atoms. Amins, sulphinic-acids, oxythionaphthene, indoxyl or their derivatives and in general all compounds containing reactive hydrogen atoms are suitable for the condensation. It seems that the condensation takes place in the same manner as with naphthoquinones, the element connected with the reactive hydrogen atoms going in orthoposition to one of the quinone-oxygen-atoms, whereby leuco-compounds are produced in the first place with change or may be converted into vat dyestuffs, either by the action of the oxygen of the air or by the employment of other means of oxidation.

They are reddish-brown powders, difficultly soluble in the usual solvents. They may be crystallized from hot glacial acetic acid. With alkaline hydrosulphite they give a yellow vat, from which wool is dyed brown.

24.7 parts of the quinone obtainable from the 1.2-pheno-5-oxynaphthocarbazole are suspended in about 250 parts of water, and 15.6 parts of toluene sulphinic acid are added. The mass is acidified with some hydrochloric acid and heated and stirred on the water-bath for some hours. It is then made alkaline and air is blown through it, until the dyestuff is fully oxidized. The precipitate of a brown color is drained off and washed with water.

The dyestuff yields with alkaline reducing agents a yellow vat, from which wool is dyed with fast brown tints. (1,261,858, Apr. 9, 1918.)

Vat Dyestuffs.—MICHAEL ILJINSKY of Uerdingen-on-the-Rhine, Germany, patents a process of making vat dyes. The invention relates to vat-dyestuffs containing sulphur with an anthraquinone molecule, which are obtained by dry heating of anthraquinone or anthraquinone derivatives with thiosulphates. If for example anthraquinone-sulphonic acids or their salts are heated with thiosulphates, products which can easily be vatted and which take upon cotton in powerful fast tones are formed, while sulphur is liberated. The products of the process mentioned in German Patent 95484 are black sulphur dyestuffs and they are dyed from sodium sulphide solution. The products of the present invention are insoluble in sodium sulphide solution, they are dyed from alkaline hydrosulphite vats and they give olive-colored tints. Also the products resulting from the process described in German Patent 226879 (Example 3) are not identical with those of the present invention. Apart from the difference in color, the dyestuffs prepared according to that specification are all soluble in concentrated sulphuric acid, whereas the new products are insoluble in concentrated sulphuric acid. For the preparation of sulphur dyestuffs, thiosulphates have heretofore many times been employed, but hitherto always in aqueous solutions and with addition of alkali. The present process on the contrary proceeds in the absence of water and alkali, the reacting mixture remaining dry during the whole process. Such thiosulphate melts (if "melts" may in this case be spoken of at all) have not previously been produced. The specification states that it is surprising that under such circumstances the substances enter into reaction. Comparative experiments have demonstrated that for example a mixture of dry sodium anthroquinone-sulphonate, sulphate and sulphur, does not react in a similar manner under the same circumstances. (1,261,394, Apr. 2, 1918.)

Phthalic Anhydride.—THOMAS D. GREENLEY of Glen Ridge, N. J., patents a process of making phthalic anhydride which he assigns to the Ellis-Foster Co., of New Jersey. The process is described as follows:

The first step in the operation is to prepare as an activator or accelerator of reaction a quantity of sulphate of mercury which may be produced by heating and stirring 10 lb. of mercury with 100 lb. of oleum containing 20 per cent SO_3, the temperature being raised to 200 deg. C. and maintained at that point with constant agitation for a period of about one hour. If mercury sulphate is available from other sources or from a preceding run, it is not necessary to prepare the sulphate in this manner. 30 lb. of naphthalene are dissolved in 100 lb. of oleum of the same strength as the foregoing and this solution or mixture is added to the mercury sulphate in acid solution prepared as above set forth. The mixture is heated in a retort to 250 deg. C. and is maintained at this temperature until about one-half of the reaction mass has distilled over. During this heating and distilling operation the reaction mass may be well agitated and to this end the retort is equipped with a stirring device which may be operated so as to give a mild to vigorous agitation, depending upon the size and shape of retort and conditions of operation. In any event, preferably the agitation is carried out in such a manner as to secure a satisfactory intermingling of the reacting constituents. The mass is then cooled to about 200 deg. C. and 100 lb. of oleum are added. The temperature is then raised to about 250 deg., the other conditions being the same as the foregoing. After distillation has been completed to about one-half the volume of the reaction mass, 150 lb. of oleum are added and the temperature carefully raised to about 300 deg. C. The distillate may then be filtered, treated with caustic soda solution and again filtered, the alkaline solution neutralized and evaporated to dryness. To purify, the mass is heated to the subliming point of phthalic anhydride the product is suitably collected and may be purified as desired. (1,261,022, Apr. 2, 1918.)

Refractories

Bonding Kieselguhr Powder.—CHARLES S. KINNISON of Birmingham, England, proposes to bond Kieselguhr so that it may be molded into any desired shape by adding soda-ash solution and drying. Best results are obtained by using 8 to 15 per cent of soda ash and 92 to 85 per cent of Kieselguhr. It is thought that sodium silicate is formed in the drying process. (1,259,525; Mar. 19, 1918.)

Potash

Potash from Kelp.—FRANK K. CAMERON of Salt Lake City, Utah, patents a process of obtaining potash salts from kelp, which he assigns to the Alaska Products Co., of New York. The process comprises mincing and straining the kelp in such a manner as to produce thorough aeration, adding an acid flucculating agent (hydrochloric acid) to produce a floating separation of coagulum from the clear liquor, returning the floating coagulum for treatment together with fresh kelp in the straining operation and evaporating the liquor to crystallization. (1,259,486; Mar. 19, 1918.)

Potash from Leucite Rock.—FRANZ A. RODY of Newark, N. J., patents a process of obtaining potash from silicate rock and other silicates such as leucite, feldspar, etc. The patent is assigned to the Metallurgical Co. of America, of New York. The method comprises fusing about one hundred parts of crude leucite, reducing it to a powder of one hundred mesh and then digesting for about an hour with water and about six parts of lime at a pressure of one hundred pounds per square inch, thereby bringing the alkalis into solution. (1,260,944; Mar. 26, 1918.)

Explosives

Nitro Compounds from Tar Oils.—JOHN R. MARDICK of New York, patents a process of making nitro-compounds from tar oil raw materials containing

several per cent of compounds removable by crystallization and repeated washings, not exceeding three, with 2½ to 5 per cent by weight of sulphuric acid and 5 per cent solution of soda ash, (1) coal tar distillate having a sp.gr. from 1.00 to 1.10 (2) impure water-gas tar distillate having a sp.gr. of 0.95 to 1.08; (3) producer-gas tar distillate having a sp.gr. of 0.95 to 1.08; (4) the first two-thirds of the entire distillate of coal tar; (5) the distillate of a tar or mixture of tar distillates having a sp.gr. between 0.95 to 1.10. The following special nitration process is used as distinguished from the processes customarily employed for nitrating pure benzol, toluol, etc. In operating for example upon coal-tar distillate having a sp.gr. of 1.00 to 1.10 one and one-half parts of an acid mixture consisting of 45 per cent HNO_3, 38 per cent H_2SO_4 and 17 per cent H_2O is used, the acid mixture having a sp.gr. of 1.54 to one part of the aforesaid material, the same being mixed by the gradual addition of the said acid to the oil over a prolonged period of time, preferably about 7 to 8 hours and the temperature of the nitration bath being maintained by means of constant stirring and cooling, during the first two hours between 25 to 30 deg. C., the next three hours between 30 and 35 deg. C. and the last two hours between 35 and 40 deg. C. with the extreme limit preferably 45 deg. C. and in no case above 60 deg. C. After the nitration has been completed, the acid bath beneath the nitro-compounds is withdrawn in the manner customary in the manufacture of tri-nitro-toluene and nitro-glycerin, and the nitro-compound is then drowned in water in the well-known manner by throwing the same into a large volume of water and then thoroughly washing the resultant nitro-product in a suitable vessel with the water maintained at a temperature of about 40 deg. C. The washing operation is preferably repeated about three times. After the washing the nitro-compound obtained is removed to a kneading machine and washed with several changes of water, about three, or until the water shows no substantial acid reaction. Then a small amount of magnesium carbonate is added to neutralize the acid and the material is thoroughly agitated, whereupon it is again washed with water and any soluble crystalline salts are washed out. (1,258,587; Mar. 5, 1918.)

Electrolytic Zinc

Electrolytic Process.—HERBERT R. HANLEY, of Winthrop, Calif., (assigned to Bully Hill Copper Mining and Smelting Co.) patents a zinc extraction process to increase the amount of water-soluble zinc compounds by an acid roast, to remove impurities, and to produce sulphuric acid as a by-product. Sulphide ores should be first roasted to give the maximum amount of sulphates, then this calcine, oxidized zinc ore or fume is mixed with 50 per cent sulphuric acid to form a thick mud (approximately 30 pounds of acid per hundred of ore). The mixture is air dried, then for twelve hours in a flue drier, when the cake is broken to ½ inch and roasted at temperatures ranging from 260 deg. C. at the cold end (200 deg. C. minimum) to 500 deg. C. at the hot end (650 deg. maximum) converting substantially all zinc compounds into water-soluble sulphates, and volatalizing arsenic and selenium. The hot calcine is agitated with water to produce a solution of 1.27 specific gravity and purified in the usual way. An electrolyte preferably containing 120 grams zinc sulphate per liter is then deposited with air agitation until the zinc has fallen to the lowest percentage practicable considering the expense of the current used. The spent electrolyte now contains alkaline and zinc sulphates as well as sulphuric acid and is evaporated to the concentration necessary so it may be added to the beginning of a new cycle. In this process the bulk of the magnesium sulphate will crystalize out, together with a quantity of alkaline sulphates depending upon the amount of zinc remaining in the solution. This sulphate radicle lost is supplied in the primary roast—it may even be necessary to continuously remove an excess of acid so formed. (1,241,966, Oct. 2, 1917.)

Aerating Anode.—Mr. Hanley also patents an aerating device serving also as an anode, illustrated in Fig. 1. The aluminium cathode 2 is suspended between

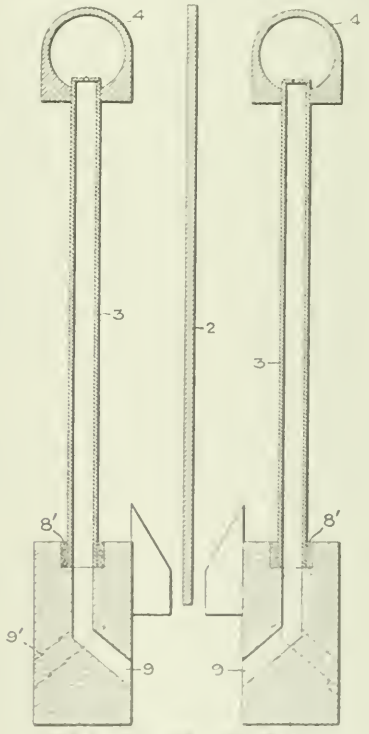


FIG. 1.—COMBINED ANODE AND AERATING DEVICE

a series of lead pipes 3 acting as insoluble anodes. The pipes receive an air supply from a manifold 4 placed above the solution and discharge it at reduced pressure to alternate sides of a nonconducting base 8 fixed across the tank, through openings 9 so large as not to be plugged up by crystals or slimes. The air bubbling up along the face of the cathode brushes off the polarizing hydrogen film, and thus increases the current efficiency. (1,241,967, Oct. 2, 1917.)

Electrodeposition in Strongly Acid Solutions.—U. C. TAINTON and J. N. PRING of England have formerly patented a process (No. 1,059,233) consisting of adding to the zinc solution to be electrolyzed a large percentage of acid and a small proportion of a colloid, and electrolyzing with a current of high density. They now find that some of the advantages of this process can be secured without the colloid, if conditions do not require a smooth and lustrous deposit. A saturated solution of zinc sulphate, for instance, to which was added 16 per cent of sulphuric acid was electrolyzed at a current density of 600 amperes per square foot, obtaining firm deposits with a current efficiency of 94.6 per cent. (1,247,179, Nov. 20, 1917.)

A New Method of Extinguishing Chemical and Oil Fires

The problem of protecting gasoline, oils, chemicals and other inflammable liquids from fire has always been a pressing one. Recently a method of attacking this problem has been devised, which consists in covering the burning surface with "firefoam," which is essentially a carbon dioxide foam very light in specific gravity which floats on the burning surface and snuffs the fire out.

As is generally known it is useless to attempt to extinguish oil, gasoline or chemical fires with water or ordinary fire extinguishers. Water sinks to the bottom of the liquids, or putting it in other words, the burning liquids float on the water and the fire is not extinguished. If extinguishing gases are used they are blown away by the draft of the fire and very little good is accomplished, especially if the fire is of any great magnitude.

This new method of extinguishing fires confines the carbon dioxide gas in a thick, tough blanket of foam, which floats upon the lightest liquids, cutting off the air supply from the fire. The substance is claimed to be quite permanent, lasting an hour or more, which prevents the possibility of the fire reflashing.

The product has been developed by the Erwin Manufacturing Co. of Milwaukee, who have designed special apparatus for applying it so that tanks even 40 or 50 feet or larger in diameter containing inflammable liquids can now be given protection from fire.

Pure Sheet Nickel Now Available for Industrial Purposes

During the past few years there has been a great deal of activity in the promotion of pure nickel and nickel alloys in various forms for manufacturing purposes.

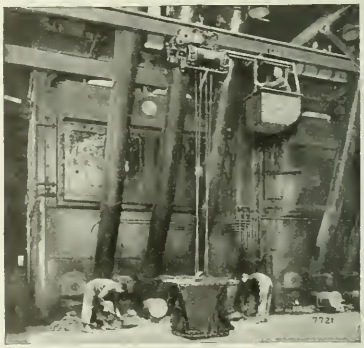
Pure, solid nickel is not the same as the inferior metals usually sold as nickel, such as are used in nickel watch-cases and other manufactured articles which consist mostly of steel, brass or German silver with a thin plating of nickel. This plating wears off in a short time. Pure nickel does not rust or oxidize; it will not tarnish like silver or some of the alloys, such as German silver, and there is no danger of corrosion resulting in the surface being injured as with a plated material. It is not attacked by acids or alkalies in the dilute form, like copper and its alloys, and is practically immune to the attacks of all alkalies regardless of their strength, and is largely resistant to the action of most acids. Nickel also has a very high tensile strength, which is among its chief advantages when used as an acid resisting metal, as there are very few of the other metals which will resist these corroding elements and at the same time have sufficient strength to fit them for many purposes in the chemical field. Pure nickel, when manufactured in the form of sheets, being homogeneous, in addition to its great tensile strength, is very ductile and easily formed by spinning or stamping. Specially formed articles for use in manufacturing chemical equipment can be manufactured from nickel without using any special equipment except that as employed in manufacturing articles from German silver or other hard alloys. Pure nickel tubing is being manufactured and can be supplied in quantities and in all the commercial sizes.

The increase in the cost of copper and its products has brought this to a point where pure nickel can be compared favorably with it as to initial cost. The service and long life of nickel cannot be compared with the common metals.

There are many uses for this metal in the chemical field. Many parts of chemical apparatus require a metal which will withstand the action of corroding elements without deterioration. Facilities for manufacturing pure sheet nickel have been provided for by the Driver-Harris Company, of Harrison, N. J., and for the manufacture of tubing, by the Newark Tube & Metal Works, Newark, N. J.

Handling Ashes with Electric Hoists

The problem of handling ashes mechanically is becoming more urgent, and a mono-rail electric hoist with a bottom dumping bucket has been developed by the Link-Belt Company of Philadelphia, Pa., for this purpose. A photograph of this hoist, in use at the plant of



MONO-RAIL HOIST FOR ASH HANDLING

the Philadelphia Paper Company, is shown in the accompanying drawing.

This machine runs on the lower flange of an I-beam track. It is operated by a man traveling in a trailer cage, who controls the raising or lowering of the bucket, as well as the travel of the hoist. About thirty tons of ashes are handled daily at this plant and are pulled out every six hours.

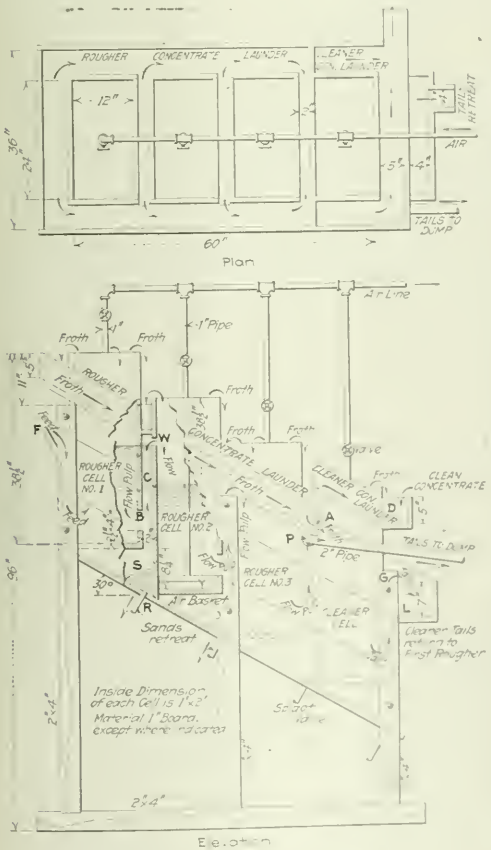
A New Flotation Machine

By A. W. Fahrenwald

THE flotation machine shown in the accompanying illustrations was designed by me for the Texas State School of Mines, to be installed in the testing mill now under construction. To conform with the capacity of the rest of the mill it is designed to treat from 300 to 400 lb. per hr.

The apparatus as shown in the two views consists, in the main, of four cells identical in shape and size. The first three are for roughing and the fourth one for cleaning the concentrates from these. The cells are inclined at an angle of 30 deg. with the horizontal giving a drop of 9½ in. from cell to cell. This drop gives a gravity flow to the pulp in passing through the machine. The distance between cells is 2 in. for this testing machine. For larger capacity in mill work this would be increased somewhat. For large capacity the length of each cell would also be increased to 2½ ft. and the width to 8 to 10 ft. depending upon the tonnage required. The machine is self-contained, which is convenient for testing work. It is easy to operate and requires little attention.

Following the passage of pulp through the machine, the feed enters at the point F, and thence into the rougher cell No. 1. Here the pulp is subjected to the usual pneumatic action where a concentrate froth is formed; this builds up and flows over the four sides of the cell as indicated by the arrows, into a launder which serves the three roughing cells. From roughing cell No. 1 the pulp passes under the baffle B and up the rectangular channel C, between the first and second roughing cells, into roughing cell No. 2. The opening in roughing cell No. 2 controls the height of pulp level in cell No. 1. A similar opening in cell No. 3 controls the pulp level in cell No. 2 and so on through any number of cells. A pipe P for discharging tailings, controls the pulp level in the last roughing cell. The froth overflow from the three roughing cells passes down a common launder into the cleaner cell through the opening A. In this cell a clean concentrate is produced and a tailing overflow at G which is returned to the first roughing cell.



FAHRENWALD FLOTATION MACHINE

The arrangement of cells described is not limited to three cells in series, but three would ordinarily be sufficient. The capacity of the machine can be varied from a very small amount up to the maximum at which point some flotable sulphide would be discharged with the tailings. The operation of the machine is simple and does not require any great amount of care. The only adjustment necessary is that of the air which is accomplished by the use of one main valve. The gate W can also be made adjustable.

In this machine it is possible to treat a feed containing sands. Particles that are too heavy to be carried up the channel C, by the uprising current of pulp, settle down into the pocket S where they can be removed intermittently or continuously through the spigot valve R. For a feed containing sands the first cell would act as a classifier, the sands being sent back to the grinding machine. This opening also affords a way of cleaning out the machine after each test.

The form of bottom used for injecting air into the pulp consists of a top and bottom ribbed casting between which is clamped four thicknesses of canvas. A projection passes up through a hole in the center, connected to a ¼ in. air line. The air is forced underneath the canvas and up through it. There is no leak through the hole in the canvas which fits over the projection since it is clamped between the bottom and top pieces by four bolts at the center in the same way as at the edges.

The machine for testing purposes is self contained; the height of pulp level in each cell is controlled by an opening in the side of the succeeding cell; the froth formed over flows on four sides of each cell, thus giving each particle of concentrate a minimum distance to travel in leaving the machine; the porous bottoms for injecting air into the pulp are lowered into the cells from above and the removal of one for repair does not interfere with the operation of the other cells; it is simple in construction and of low first cost, the pulp passes over a weir the entire width of the machine which gives the individual particles a better chance to be floated than if the same mass of pulp entered the cell through a pipe which overloads the machine in that immediate vicinity.

El Paso, Texas

Automatic Electric Furnace Control

WITH the advent during the past year of 20-ton electric furnaces and indications of an advance to a standard maximum of 30 tons, the General Electric Company developed an improved system of automatic control to handle the motive power necessitated.

These improvements became necessary as the rate of steel production in these furnaces had been increased by the use of higher capacity transformers and higher voltages, which permitted forcing power into the furnaces at considerably higher rates.

The control panel is made in three sections, as shown in Fig. 1. The top section contains three shunt relays and three contractor groups; the total number of each being in accordance with the number of electrodes used. The middle section has three contact-making ammeters each provided with dashpots to prevent hunting, and with coils provided with taps which are used to vary the amount of power supplied to the furnace. Beneath are three small dial switches which are connected to the coil taps. On the lowest section there are four d.p.s.t. knife-blade switches with fuses, one switch being used for the line and the other for the electrode motors.

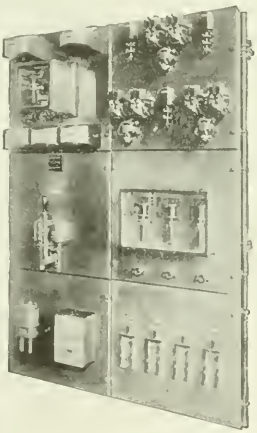


FIG. 1. CONTROL PANEL

Each contactor group consists of three units all mechanically interlocked, two contactors being normally open and one being normally closed.

Facing the panel, the left-hand contactor of any group makes the necessary connections to raise the electrode, while the right-hand contactor causes the electrode to be lowered and the bottom contactor short-circuits the motor armature through a resistance, in this way dynamically braking all moving parts and stopping them almost instantly. A higher resistance is connected in circuit with the armature when lowering than when raising, this being done to keep the speed approximately constant.

The shunt-wound electrode motor is connected to the line until the desired regulation is obtained, when the motor is disconnected and stopped almost instantaneously by means of dynamic braking, this method giving the simplest and most positive control of the electrode movement. The type of motor used was designed for this particular service, especially in regard to self-lubricating bearings, and ranges in size from 1 to 1½ hp. for small equipments, to 5 hp. for 15- to 20-ton furnaces.

The higher power used can be seen by taking for example, the 6-ton furnace, which is the size in greatest general use. The transformer capacity has increased from 900 kv-a. to 1500 kv-a., and even 1800 kv-a. has been proposed, all these capacities being based on 100 volts. In the variable voltage equipments the successful use of 150 volts renders it possible to increase the normal 1500 kv-a. up to 2250 kv-a.

Although 100 volts remains standard for refining, voltages up to 173 have been used for melting, these voltages being obtained either by high-voltage taps or high-voltage Y-data.

Fig. 2 shows a connection diagram of 3-phase furnace arranged for variable voltage operation by means of changing high-voltage connections. The high-melting voltage is obtained by connecting high-voltage windings delta, and the low-refining voltage by connecting them "Y."

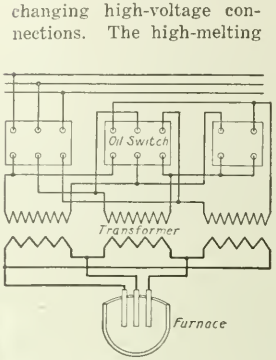


FIG. 2. THREE-PHASE FURNACE ARRANGED FOR VARIABLE VOLTAGE OPERATION

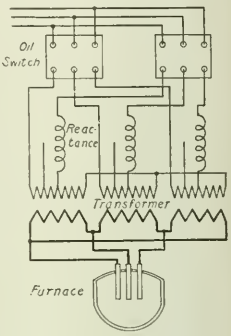


FIG. 3. CONNECTION DIAGRAM OF FURNACE EQUIPMENT USING REACTANCE

When it is considered desirable to use external reactance with high-voltage taps, the method shown in Fig. 3 is used. Variable voltage is obtained by means of high-voltage taps and external reactance is provided to be cut in during the melting period.

The use of high voltages during melting down, permits of decreasing the current for a given input, improves the power factor and insures higher emergency input when most needed.

Book Reviews

TREATISE ON APPLIED ANALYTICAL CHEMISTRY, by Professor *Vittorio Villavecchia*, Director of the Chemical Laboratories of the Italian Customs, translated by *Thomas H. Pope*, B. Sc., A. C. G. I., F. I. C., University of Birmingham. 1918, Vol. I. Price $6.00. 476 pages and 58 illustrations. Philadelphia: P. Blakiston's Son & Co.

One picks up this volume expecting to find a treatise on methods of separation as well as the customary opening chapters on weighing, filtering, igniting, etc.; but one is surprised to find that it is a compendium of analytical and other tests of economically occurring substances. The capitulation is by name of material or class. Chemical products are treated individually and in alphabetical order. Then follow chapters on classes of substances and materials such as fertilizers, cement materials, metals, fuels, coal-tar, oils and fats. Even stable manure has a place as a complex fertilizer. Asphalt appears to be overlooked; rubber, paints and glass likewise. There is much material of a non-analytical or non-chemical text throughout as a consequence of this method, resulting in chapters or paragraphs on such subjects as technical tests of cement and

photometric tests of illuminating oils. There are tests described for the thoroughness of metallic coatings, gilding, silver and nickel plating, oxidizing, etc. The translator's work is excellent, but at times his art is not concealed. Thus "newly won" in the following sentence, "When newly won, lignites contain 20-60% moisture" may be good rendering of a happy Italian phrase, but in English it is not colloquially technical or technically colloquial. As a whole the work is extremely valuable for its full compilation of specific tests and criteria, standards and requirements for commercial purity of industrial chemical substances.

* * *

ELECTRIC FURNACES IN THE IRON AND STEEL INDUSTRY. By *Rodenhauser* and *Schoenawa*. Translated from the German by *C. H. Vom Baur*. Second edition, octavo (14 x 22 cm.), xviii + 429 pages, 135 illustrations. Price $3.75. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

The first edition of this noteworthy book, appearing in 1913, made its mark, and was duly reviewed by us. This new edition has been largely re-written, and much new material added to keep pace with the developments of the last four years. We would like to have seen a fuller description given of the Heroult furnace, since it is the one in largest use, and more complete directions as to using burned dolomite instead of burned magnesite in making up furnace hearths, since the former is more sensitive to impurities than the latter, and account should be taken of that fact. Yet, there is no other book in English which covers this ground so thoroughly and satisfactorily; it is invaluable to the iron and steel metallurgist, and highly instructive to all using or interested in electric furnaces.

* * *

LUBRICATING ENGINEERS' HANDBOOK. By *John Rome Battle*. 334 pages. Illustrated. Price, $4.00. Philadelphia: J. B. Lippincott Company.

The author of this book has produced a very commendable work, both in the theory and practical application of lubricants, and the book should appeal to those interested in lubrication in general.

Considerable extraneous information is included in the book, which is more of a mechanical engineering than of a lubricating nature, and many pages have been covered with matter of a purely descriptive nature regarding various machines, their moving parts, and other apparatus used in the industrial arts. Such miscellaneous information as has been included can be found in most good books on mechanical engineering and it appears somewhat out of place in a book devoted to lubrication. Almost every kind of a machine and apparatus requiring lubrication has been described along with the principles of their lubrication. Very little literature pertaining to lubricating oils and their application has been written; consequently for those seeking general information on this subject the book should prove of interest. As a reference work, however, the book would not appear to be very useful, as the subject matter is too general in nature. The book is well written in language understandable by the layman, and the subject matter is arranged in logical sequence; the type is large and easily read, on good paper, and the illustrations are numerous.

* * *

HYDRO-ELECTRIC POWER STATIONS. By *Eric A. Lof* and *David Rushmore*. Price $6.00. New York: John Wiley & Sons, Inc.

A timely interest attaches to any book on this subject owing to the impending reawakening of hydro-electric development. The present treatise gives an outline of current practice in the various phases of engineering involved. The authors claim that "this book deals with and explains the problems which must be solved in connection with the construction and management of a hydro-electric power station, so that the manager or engineer may select power equipment and fully understand the economic factors which enter into each individual situation." Unfortunately the book does not do this in as large a measure as could be desired. The discussion of the fundamental problems involved is too meagre and too much wanting in critical quality to be much of a guide either to the student or the engineer. On the other hand the book furnishes a fairly complete picture of standard practice at the present time, particularly in regard to the electrical portion of the subject. It is in this phase that the authors of course are chiefly interested; and this probably accounts for the fact that about 300 pages of the book have been devoted to matters concerning electric generation, transformation, transmission, etc., that are in no way peculiar to hydro-electric power generation. The dearth of books on this subject impels us to admit, however, that we know of no more satisfactory treatise; and for a really satisfactory one we shall probably have to wait until the subject is tackled by some engineer whose experience on the anterior side of the turbine coupling is equivalent to that of the authors on the posterior side—and that may be a long while.

* * *

THE JOURNAL OF THE INSTITUTE OF METALS, Vol. XVIII. Edited by *G. Shaw Scott*, 21 -net. The Institute of Metals, 36, Victoria Street, London.

There is continued in the present volume the invaluable discussion on metal melting that was inaugurated by the institute last year. A new system of gas-firing is described which is claimed to enable metals to be melted exceedingly economically and which effects great savings in coal. The possibilities of using powdered coal for brass melting are fully discussed by numerous fuel experts.

Though brass is so important for war work and so much space is devoted to its consideration in the *Journal*—notably in the case of Dr. Parker Haigh's article "Experiments on the Fatigue of Brasses"—other of the non-ferrous metals and alloys that the Institute of Metals exists to study receive attention. Thus we find Professor H. C. H. Carpenter, who is to be this year's president of the institute, contributing a valuable paper, jointly with Lieut. L. Taverner, on the effects of heat on aluminium sheet. Other metallurgical problems discussed relate to high temperature thermostats, the effect of hydrostatic pressure on metals, and etching re-agents. A valuable treatise is given by Professor T. Turner, on "Hardness and Hardening," in which the latest views upon this subject are ably summarized and discussed.

Engineers will be specially interested in Professor W. E. Dalby's full and completely illustrated account of the researches that he has made with the aid of his remarkable "autographic load-extension optical indicator."

The volume under review concludes with a section in which concise abstracts are given of all recent literature bearing on metals.

* * *

EYE HAZARDS IN INDUSTRIAL OCCUPATIONS. By *Gordon L. Berry*, Field Secretary, National Committee for the Prevention of Blindness, with the co-operation of Lieut. Thomas P. Bradshaw, U. S. Army, formerly Technical Assistant to the Director of the American Museum of Safety. (Octavo, 150 pp., illus.) Published by the National Committee for the Prevention of Blindness, 130 East Twenty-second Street, New York. Price, 50 cents.

In this volume the author reviews the chief industrial hazards to eyesight in the industries of the United States. Case reports illustrate each section, the special dangers are described and recommendations made for such changes of working conditions, or installations of protective devices, as have been found suitable for protecting workers. The book is most completely illustrated.

The following section headings indicate the scope of the book: Statistics of Eye Accidents, Chipping Operations, Machine Operations, Abrasive Wheels, Sand-Blasting, "Mushroomed" Tools, Riveting, Radiations from Intense Light and Heat Sources, Ultra-violet Rays in Illuminants, Radiant Energy in Arc Welding and in Molten Metal, Metallurgical Operations, Glassblowers' Cataract, Infections, Gage Glasses, Acids and Chemicals, Treatment of Acid

Burns, Industrial Poisons, Removal of Dangerous Fumes, Vapors and Gases, Spray Process Hazards, Methyl Alcohol, Bottling Accidents, Mining and Quarrying, Agricultural Hazards, Goggles, Garment Trade Hazards, Industrial Lighting, the Safety Movement.

These subjects have been treated not so much in the way of a technical manual for safety engineers, but rather in a general informative way for the information of the average manufacturer or layman who is seeking information of this nature. Descriptions of many of these hazards have been included heretofore in publications covering the complete field of industrial accident prevention, and where discussion of preventive measures would be repetition the author has referred his reader to the chief of those sources where such detailed information might be secured, if desired.

Much of the "laboratory work" in the preparation of this book was accomplished in Buffalo, New York, where at the invitation of a large group of leading citizens a study was made of the eye hazards and methods in vogue for accident prevention in representative industries of that typical manufacturing city.

The book is the most complete compilation of material relating solely to the prevention of eye accidents that has been published in this country. Inasmuch as there occur annually in the United States alone nearly 200,000 eye accidents, from which many cases of total blindness result, it would seem that there is need for further attention to this important subject.

Personal

Mr. R. C. Bergen, assistant editor of Metallurgical and Chemical Engineering, has resigned to go into chemical manufacturing work. He has been connected with this journal since its change to a semi-monthly in 1915 and was formerly chemical engineer with the Roessler & Hasslacher Chemical Co., at Perth Amboy, N. J.

Mr. Charles Philip Coleman has been elected president of the Worthington Pump and Machinery Corporation. Mr. Coleman advances from the position of vice president, held since May, 1916, to the presidency. He was, prior to that date, receiver of the International Steam Pump Company and associate companies, which have now been reorganized into the present corporation, which owns and controls large works manufacturing pumping machinery and affiliated lines.

Mr. Francis C. Frary, research chemist of the Aluminum Company of America, has been commissioned as captain in the ordnance reserve corps and assigned to research work in the trench warfare section, Engineering Bureau, office of the Chief of Ordnance, Washington, D. C.

Mr. H. E. Ives, formerly with the United Gas Improvement Company, Philadelphia, Pa., has entered the science and research division of the United States signal corps and is now stationed in Washington.

Mr. Henry H. Mandle has resigned from his position as chief of the technical staff of Herman & Herman, Inc., and has reverted to his former practice as a consulting chemical engineer with offices at 220 West 42d St., New York. Mr. Mandle has also become interested in the National Bronze & Chemical Works, for whom he is acting in the capacity of technical adviser.

Mr. Louis S. Munson, associated with the Ault & Wiborg Company, Cincinnati, O., for the past eleven years in the capacity of chemist, has resigned to take charge of the production department of the new dye plant being erected by the du Pont's on the Delaware River near Wilmington.

Dr. J. C. Olsen has accepted the position of Professor of Chemical Engineering and Head of that department at the Polytechnic Institute of Brooklyn. A new chemical engineering laboratory is to be equipped and installed at the Polytechnic Institute, and more emphasis given to the course in Chemical Engineering, both day and evening. Considerable more space is available for the work in Chemistry since the Institute has taken over the building used by the Preparatory Department. This building has been thoroughly overhauled and put in first-class condition. New chemical laboratories will be built in this building.

Mr. Charles M. Schwab, chairman of the Board of Directors of the Bethlehem Steel Corporation and president of the Bethlehem Shipbuilding Corporation, has been made Director General of the Emergency Fleet Corporation. He will devote all of his time to "speeding up" shipbuilding and has arranged to have the offices of the Fleet Corporation removed to Philadelphia, which is the center of shipbuilding in the East. He will have no connection with the letting of contracts.

Mr. E. Gybbon Spilsbury has returned from Cuba, where for the last two months he has been studying the manganese situation.

Mr. A. E. Ward has been appointed sales manager of the International Oxygen Co., 115 Broadway, New York. Mr. Ward was formerly with the Prest-O-Lite Company and for many years has been associated with the compressed gas industries.

Current Market Reports

The Iron and Steel Market

The chief development of the past fortnight in the iron and steel situation has been a clear realization that the war requirements in steel are greater, in proportion to productive ability, than had been estimated. The steel makers find occasion to consider more seriously the matter of supplying adequately all the war activities, and particularly that of shipbuilding, than they had previously felt was necessary.

There have been some misunderstandings, which have been ironed out, and the steel makers are simply addressing themselves more strenuously to the task. It appears that the work of shipbuilding is accelerating more rapidly than was previously apparent. The vessel launchings of late, of which there have been precise statistics, are not a measure of the work that is proceeding. In other words, steel is being fabricated at the shops tributary to the shipyards at such a rate as to presage in due course a much heavier rate of vessel launchings, and vessel completion, than has obtained in the past few weeks.

The requirements in steel for our allies have visibly increased. It appears that some requirements were withheld from trade knowledge. In the past two or three weeks the trade has learned, for instance, that according to trustworthy reports General Pershing quietly borrowed from Britain and France steel in various forms representing a total of over 700,000 tons, and this steel General Pershing merely notified the Government it would have to find in the United States and ship abroad, to repay the loan. Of this particular amount 300,000 tons is to be in ship plates for British yards, while there are other and direct requirements in the same quarter.

From all that can be learned there is occasion to expect that iron and steel exports to our allies for the remainder of the year will be at a materially greater rate than has obtained in the past few months. This has a double influence upon the steel trade, for there is not only the increase in exports to be reckoned, but also the fact that exports in recent months have been made up rather largely of steel that had been accumulating for a long period on the Atlantic seaboard. Lately the shipments from mills, for export, have been much less than the tonnage actually leaving the country.

With these new developments it appears that a larger amount of steel will be required for prosecuting the war than was represented by the appraisals current at the beginning of April. With production unchanged from anticipations, the supply of steel remaining for purely commercial purposes, not connected with the war, will be less than had been expected.

The iron and steel market has given concrete testimony to the situation now confronting the trade. Since about

the first of March shipments of pig iron and of finished steel products to commercial consumers have been much greater than in the first two months of the year, probably at least twice as great. In some quarters it was thought that such an increase would soon result in commercial consumers being fully supplied. Their requirements are, of course, much less than before the country became as fully engaged in prosecuting war as it now is. On the other hand, it is quite certain that the requirements have increased over those of early in the year, when consumers were hampered in their operations, just as producers were.

There has been no material increase in production in April as compared with March. The output of pig iron has been larger, but there has hardly been a commensurate increase in the production of steel. Shortage of scrap is distinctly in evidence. The mills must now depend chiefly upon their own scrap and such as is obtained from industrial consumers engaged in war work. The usual flow of old material into consumption is quite generally arrested, as there is little new construction of a character that would displace old material, whether in industrial or municipal operations, or in the railroad field.

The restriction to blast furnace operations in the central west through insufficient car supplies in the Connellsville region has been fully as great in April as in March, when there was a noteworthy improvement over conditions in January and February. The furnaces dependent upon by-product coke now have practically full operation, and in occasional instances furnaces formerly dependent entirely upon Connellsville coke have been able to secure by-product coke, a surplus over the producer's own requirements. For a complete solution of the coke situation in the central west the completion of additional by-product ovens may perhaps have to be awaited. Ovens with a capacity of about 100,000 tons of coke a week are scheduled for completion within a few months.

On the whole, operations in the iron and steel industry have been at the rate of about 85 per cent of capacity in the past two months, with no great changes from week to week. The output is approximately equal to the average output in 1916, but the capacity, by reason of new construction, is much larger. The tonnage that represented full operation in 1916 now represents an average of about 85 per cent operation. In view of the great decrease that has occurred in the commercial, or peace, consumption of steel since 1916, it is obvious that an enormous tonnage is released, voluntarily or otherwise, for prosecuting the war.

The markets have been very quiet. Nearly all shipments are in connection with war operations, or against old commitments by ordinary consumers, whose deliveries have been greatly delayed. Throughout the market prices are at the prescribed maximum limits.

Non-Ferrous Metal Market

Monday, April 22.—There is nothing much to report in copper and tin. Lead and spelter continue weak. The price of nickel has been fixed by agreement. Antimony is unchanged.

Copper.—Consumers have been able to obtain sufficient supplies for their purposes and as the refinery production is increasing there is no sign of any copper shortage. The price remains as fixed by the Government at 23½c. per pound for producers and 24.67½c. per pound for jobbers.

Tin.—New business in tin is practically at a standstill as Chinese tin is held at a very high price and other brands are off the market. Australian tin for future delivery has appeared on the market at about 85½c. for June shipment. Arrivals at Atlantic ports up to April 17 were only 420 tons, mostly from the United Kingdom.

Lead.—The trust price was reduced to 7c. on Apr. 11, the actual market having been under that of the trust for some time. The market is quiet with principal producers asking 7c. New York and 6.92½c. E. St. Louis. Independents ask 7⅛ to 7¼c. New York.

Spelter.—The market continues dull with commercial spelter at 6.92½c. New York and 6.75-6.80 E. St. Louis for spot lots. May delivery at New York is quoted at 6.92½-7.02½, June at 5c. higher, and July at 5c. higher than June.

Nickel.—An agreement has been reached between the International Nickel Co., Bernard M. Baruch and the Council of National Defense, by which high-grade nickel will be sold at 40c. and the lowest grades at 38c.

Antimony.—Now quoted at 12¼ to 12½c. per pound. There are more sellers than buyers and futures are not interesting to the former, the spot market commanding most of the attention.

OTHER METALS

Aluminium, lb., 98-99 per cent, virgin, Gov't price	.32
Bismuth, lb.	2.50-2.75
Cadmium, lb.	1.40
Nickel, electrolytic, lb.	.40
Silver, oz.	.95⅝
Platinum, oz.	108.00
Palladium, oz.	150.00
Cobalt, lb.	3.25-3.50
Magnesium, lb.	2.00
Quicksilver, Cal.	123.00
Quicksilver, Mexican	118.00

Chemical Market

COAL TAR PRODUCTS: The situation underwent but little change during the interval. Some of the important crudes like benzol were in better demand, but supplies are so liberal that chemical prices are inclined downward rather than otherwise. The intermediates in general were in fair demand and prices are inclined to firm up somewhat due to restricted offerings.

Benzol: A slight improvement is reported in the buying demand, and some fairly good size contracts were closed over the year. The increase in demand, however, is not great enough to absorb the large quantities on the market and the position is very weak. It is said that sales were made at a reduction in price, where a large quantity was involved.

Phenol: There are more offerings of this material than for some time heretofore. The demand is only routine and prices are easier.

Toluol: The government has released some fairly large quantities of late to the manufacturers of dye intermediates, but there is not a great deal available. Producers are not in a position to offer except with permission by the government. Second hands are taking advantage of the situation and are exacting all sorts of prices for the small quantities on hand.

Naphthalene: Offerings are not liberal, but the demand is so light that the position is weak, though prices are quotably unchanged.

Aniline Oil: The demand has been active and second hands are pretty well cleaned out, although small scattered offerings tend to keep prices at present levels.

Aniline Salts: There has been an active export demand of late and prices have firmed up as a result. There is little or no material in second hands, so that producers are realizing their own prices.

Beta Naphthol: The technical material is in steady demand, but the production is heavy and prices are unchanged.

Para Toluidine: Although the stringency in the toluol situation has caused some producers to curtail, there is no change in price as the demand is not particularly heavy.

Sulphanilic Acid: The production is confined to a few quarters. The demand is not heavy and prices are therefore unchanged.

Phthalic Anhydride: Competition between some of the large factors has caused a drop in price; there is a fair demand.

Benzidine Base: There is a fairly active demand, but there is an ample production and prices are unchanged.

Benzaldehyde: There are only a few concerns producing this material at present; this fact coupled with the scarcity and high prices of toluol tends to drive prices upward.

Monochlorbenzol: Large quantities of this material have backed up on the market with practically no demand; a very favorable price can be done.

HEAVY CHEMICALS: Trading generally has been comparatively quiet and the volume of business has been rather disappointing. As a rule the tendency of values has been downward with the exception of special items which are extremely scarce and for which there is a very heavy demand.

Caustic Soda: The market during the past two weeks has been rather listless but has been featured by a strong market for future deliveries and a rather easier position for spot stocks. Producers have had the situation well in hand and from 5c. to 5½c. has been quoted for shipments from plant basis works freight. Spot cars have sold at from 4.50 up to 5c. Sales at the former figure have been principally due to the fact that there has been a lack of buying inquiry for these cars and the holders have in some instances been pressed for cash. A few producers have named prices for 1919 but these have been on such a high level that consumers have naturally shown but little tendency to cover. Buyers seem to feel that the new prices have been named merely to feel out the market.

Soda Ash: A lack of consuming demand and increased shipments have tended to ease off an easy situation. Barrels were for the most part rather firm but at the moment of writing have eased off and are obtainable at 2.85 spot New York. Bags have been very weak and have been quoted as low as 2.40 Philadelphia and 2.50 New York.

Bichromate of Soda: The market has not been subject to marked change during the interval but has been subject to fluctuation practically daily. Considerable speculation is still rife despite the fact that large losses have been the rule in the past in transactions of this sort. Sales of spot have occurred between 21c. and 22c. with the market occasionally up to 23c. As a rule small lots have sold at lower prices than car quantities.

Acetic Acid: This product has been one of the features of the chemical market. As has been the rule when the government assumed control of industry, prices have soared skyward with supplies almost impossible to be obtained. Producers have been disposing of production to certain approved buyers but for outside business the 20% material has sold as high as 15c. Some 56% material is held at 23c. Glacial has sold at 37c. and 38c., with sellers asking 40c. and even more.

Cyanide of Soda: While the regular trade has been asking 40c. and 42c. there have been resales from time to time at prices ranging from 38c. upward. On contract producer quotes 37c. for the soda and 32c. for the mixture for regular consumers only.

Copper Sulphate: A lack of consuming demand has resulted in practically no important business of late and resale lots have been on the market from time to time at prices ranging from 8.80 to 9.10. The regular trade has quoted from 9.25 to 9.50.

Sulphuric Acid: The production seems to have overcome the demand somewhat and acid has backed up on some manufacturers with the result that offers of sixty-six brimstone acid have been made at $35.00 sellers tanks works. The sixty degree brimstone acid has been available at $25.00 sellers tanks works. Resale lots of sixty-six acid have changed hands as low as at $32.50 New Jersey point.

Oleum: This situation has also been somewhat easier. Twenty per cent material has been rather difficult to move at $65.00 tanks and $70.00 drums, although there has not been a great deal of material offered on the open market. Sixty per cent oleum is being produced in a limited way and sales have occurred at $225 per ton.

Nitric Acid: Some acid not water white probably aqua fortis is being offered at 8¾c. works but for prime white material producers will not shade 9c. and there are makers who are holding to as high as 9.60 for the 42 degree material.

Muriatic Acid: The situation has been firm and twenty degree material is held firmly at 2¼c. as a minimum trading level at works. Offers of the 22 degree material are more restricted as the warm weather approaches and while some acid has been available at 2.50 works, generally 2¾c. and even 3c. has been obtained for moderate quantities. Carboys continue scarce and restrict the movement in all acids to a noticeable extent.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, APRIL 23, 1918

Acetic anhydride	lb.	1.35 — 1.50
Acetone, drums	lb.	Nominal
Acid, acetic, 28 per cent	lb.	Nominal
Acetic, 56 per cent	lb.	Nominal
Acetic, glacial, 99½ per cent., carboys	lb.	.40 — .41
Boric, crystals	lb.	.13¼ — .14½
Citric, crystals	lb.	.87 — .88
Hydrochloric, C. P	lb.	Nominal
Hydrochloric, 20 deg	lb.	.02½ — .02¾
Hydrochloric, conc., 22 deg	lb.	.02½ — .03
Hydrofluoric, 30 per cent., in barrels	lb.	.06 — .06½
Lactic, 44 per cent	lb.	.15½ — .16
Lactic, 22 per cent	lb.	.06 — .06½
Molybdic, 85 per cent	lb.	3.85 — ...
Nitric, 36 deg	lb.	.08¼ — .08½
Nitric, 42 deg	lb.	.09 — .10
Oxalic, crystals	lb.	.43 — .45
Phosphoric, 47–50 per cent. paste	lb.	.08 — .10
Phosphoric, ref. 50 per cent	lb.	.26 — ...
Picric	lb.	Nominal
Pyrogallic, resublimed	lb.	3.10 — 3.15
Sulphuric, 60 deg	ton	25.00 — 27.50
Sulphuric, 66 deg	ton	35.00 — 40.00
Sulphuric, oleum (Fuming), tank cars	ton	60.00 — 75.00
Tannic, U. S. P., bulk	lb.	1.30 — 1.35
Tartaric, crystals	lb.	.75 — .78
Tungstic, per lb. of W	lb.	1.70 — 1.75
Alcohol, sugar cane, 188 proof	gal.	4.93 — 4.95
Alcohol, wood, 95 per cent	gal.	.90½ — .91
Alcohol, denatured, 180 proof	gal.	.68 — .69
Alum, ammonia lump	lb.	.04 — .04½
Alum, chrome ammonium	lb.	.18 — .19
Alum, chrome potassium	lb.	.20 — .21
Alum, chrome sodium	lb.	.12½ — .13
Alum, potash lump	lb.	.08½ — .09
Aluminium sulphate, technical	lb.	.02½ — .02
Aluminium sulphate, iron free	lb.	.03½ — .03½
Ammonia aqua, 26 deg. carboys	lb.	.25 — .26
Ammonia, anhydrous	lb.	Nominal
Ammonium carbonate	lb.	Nominal
Ammonium nitrate	ton	(Fixed price) .15
Ammonium, sulphate domestic	lb.	.07½ — .08
Amyl acetate	gal.	5.00 — 5.25
Arsenic, white	lb.	.17 — .18
Arsenic, red	lb.	.65 — .70
Barium carbonate, 99 per cent	ton	80.00 — 90.00
Barium carbonate, 97–98 per cent	ton	65.00 — 67.00
Barium chloride	ton	65.00 — 85.00
Barium sulphate (Blanc Fixe, Dry)	lb.	.02½ — .02¾
Barium nitrate	lb.	.09½ — .10
Barium peroxide, basis 70 per cent	lb.	.30 — .32
Bleaching powder, 35 per cent. chlorine	lb.	.02 — .02½
Borax, crystals, sacks	lb.	.07½ — .08½
Brimstone, crude	ton	Nominal
Bromine, technical	lb.	.75 — ...
Calcium, acetate, crude	lb.	Nominal
Calcium, carbide	lb.	12½ — .13
Calcium chloride, 70–75 per cent., fused, lump	ton	27.50 — 30.00
Calcium peroxide	lb.	1.60 — 1.70
Calcium phosphate	lb.	.34 — .35
Calcium sulphate 98–99 per cent	lb.	.09 — .09½
Carbon bisulphide	lb.	.08¼ — .10
Carbon tetrachloride, drums	lb.	.15½ — .16
Carbonyl chloride (phosgene)	lb.	1.10 — 1.50
Caustic potash, 88–92 per cent	lb.	.83½ — .84
Caustic soda, 76 per cent	lb.	.048 — .05
Chlorine, liquid	lb.	.15 — .18
Cobalt oxide	lb.	1.60 — 1.65
Copperas	lb.	.01¼ — .01½
Copper carbonate	lb.	.30 — .40
Copper cyanide	lb.	75 — .78
Copper sulphate, 99 per cent., large crystals	lb.	.09 — .09¼
Cream of tartar, crystals	lb.	.63 — .65
Epsom salt, bags, U.S.P	lb.	.03¼ — .03¾
Formaldehyde, 40 per cent	lb.	.19 — .19½
Glauber's salt	100 lb.	1.50 — 2.00
Glycerine, bulk, C. P	lb.	.66 — .67½
Iodine, resublimed	lb.	4.25 — 4.35
Iron oxide	lb.	.13 — .15
Lead, acetate, white crystals	lb.	.17 — .18
Lead, arsenate (Paste)	lb.	.15 — .18
Lead nitrate	lb.	.15 — .16
Litharge, American	lb.	.09½ — .11½
Lithium carbonate	lb.	1.50 — 2.00
Manganese dioxide, U. S. P	lb.	.70 — .75
Magnesium carbonate, technical	lb.	.10½ — .11
Nickel salt, single	lb.	.14 — .15
Nickel salt, double	lb.	.12 — .14
Phosgene, see Carbonyl chloride		... — ...
Phosphorus, red	lb.	1.30 — 1.50
Phosphorus, yellow	lb.	1.50 — 1.60
Potassium bichromate	lb.	.44 — .46
Potassium bromide granular	lb.	1.35 — 1.50
Potassium carbonate calcined, 85–90 per cent	lb.	.55 — .60
Potassium chlorate, crystals	lb.	.36 — .40
Potassium cyanide, 98–99 per cent	lb.	Nominal
Potassium iodide	lb.	3.75 — 3.80
Potassium muriate 80–85 p. c. basis of 80 p. c.	ton	325.00 — 350.00
Potassium nitrate	lb.	.27 — .31
Potassium permanganate (U. S. P.)	lb.	3.80 — 4.00
Potassium prussiate, red	lb.	2.80 — 2.90
Potassium prussiate, yellow	lb.	1.18 — 1.25
Potassium sulphate, 90–95 p. c. basis 90 p. c.	ton	Nominal
Rochelle salts	lb.	.41 — .42
Salammoniac, gray gran	lb.	.17 — .18
Salammoniac, white gran	lb.	.15¾ — .16
Sal soda	100 lb.	1.35 — 1.40
Salt cake	ton	24.00 — 27.00
Silver cyanide, based on market price of silver	oz.	... — ...
Silver nitrate	oz.	.61½ — .62
Soda ash, 58 per cent., light, flat (bags)	100 lb.	2.50 — 2.60

Soda ash, 58 per cent., dense, flat	100 lb.	3 75	—	
Sodium acetate	lb.	23	—	.24
Sodium bicarbonate, domestic	lb.	.02½	—	03
Sodium bicarbonate, English	lb.		—	
Sodium bichromate	lb.	.22½	—	23
Sodium bisulphite, powd	lb.	.05½	—	06
Sodium chlorate	lb.	.24	—	.25
Sodium cyanide	lb.	.38	—	40
Sodium fluoride, commercial	lb.	.18	—	19
Sodium hyposulphite	lb.	.02½	—	02½
Sodium molybdate, per lb. of Mo	lb.	2 50	—	
Sodium nitrate, 95 per cent	100 lb.	Nominal		
Sodium nitrate	lb.	.33	—	34
Sodium peroxide	lb.	.45	—	.50
Sodium phosphate	lb.	.04	—	.05
Sodium prussiate, yellow	lb.	.41½	—	.42
Sodium silicate, liquid (60 deg.)	lb.	Nominal		
Sodium sulphide, 30 per cent., crystals	lb.	.02¼	—	.03
Sodium sulphide, 60 per cent., fused	lb.	.05¼	—	.06
Sodium sulphite	lb.	Nominal		
Strontium nitrate	lb.	.25	—	35
Sulphur chloride, drums	lb.	06	—	.06½
Sulphur dioxide, liquid, in cylinders	lb.	15	—	40
Sulphur, flowers, sublimed	100 lb.	4 05	—	4 60
Sulphur, roll	100 lb.	3 70	—	3 85
Sulphur, crude	ton	Nominal		
Tin bichloride, 50 deg	lb.	.23½	—	24½
Tin oxide	lb.	.78	—	.80
Zinc carbonate	lb.	25	—	30
Zinc chloride	lb.	.12½	—	.13
Zinc cyanide	lb.	Nominal		
Zinc dust, 350 mesh	lb.	.14	—	.16
Zinc oxide, American process XX	lb.	.14	—	.15
Zinc sulphate	lb.	.05	—	.06

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.30	—	.35
Benzol, 90 per cent	gal.		—	
Toluol, pure, water white	gal.	Nominal		
Xylol, pure, water white	gal.	.35	—	.50
Solvent naphtha, water white	gal.	.17	—	.22
Solvent naphtha, crude, heavy	gal	.13	—	.16
Creosote oil, 25 per cent	gal.	.33	—	.35
Dip oil, 20 per cent	gal.	.29	—	.30
Pitch, various grades	ton	8 00	—	20 00
Carbolic acid, crude, 95-97 per cent	lb.	1 05	—	1 10
Carbolic acid, crude, 50 per cent	lb.	.60	—	.65
Carbolic acid, crude, 25 per cent	lb.	.35	—	.38
Cresol, U. S. P.	lb.	.18	—	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1 00	—	1 25
Alpha naphthol, distilled	lb.	1 60	—	2 00
Alpha naphthylamine	lb.	.58	—	.60
Aniline oil, drums extra	lb.	.25½	—	.27
Aniline salts	lb.	.32	—	.34
Anthracene, 80 per cent	lb.	.50	—	.65
Benzaldehyde (f.f.c.)	lb.	5 25	—	5 50
Benzidine, base	lb.	1 75	—	1 85
Benzidine, sulphate	lb.	1 40	—	1 50
Benzoic acid U. S. P.	lb.	4 25	—	4 50
Benzoate of Soda, U. S. P.	lb.	4 00	—	4 25
Benzyl chloride	lb.	2 25	—	2 50
Beta naphthol benzoate	lb.	10 00	—	12 00
Beta naphthol, sublimed	lb.	.85	—	.90
Beta naphthylamine, sublimed	lb.	2 65	—	
Dichlor benzol	lb.	.12	—	.18
Diethylaniline	lb.	4 50	—	5 00
Dinitro benzol	lb.	.35	—	.40
Dinitrochlorbenzol	lb.	.40	—	.42
Dinitronaphthaline	lb.	.55	—	.60
Dinitrotoluol	lb.	.55	—	.60
Dinitrophenol	lb.	.46	—	.50
Dimethylaniline	lb.	.65	—	.70
Diphenylamine	lb.	1 00	—	1 10
H-acid	lb.	2 25	—	2 50
Metaphenylenediamine	lb.	2 00	—	2 25
Monochlorbenzol	lb.	.17	—	.19
Naphthalene, flake	lb.	.10½	—	.10¾
Naphthalene, balls	lb.	.12	—	.13
Naphthionic acid, crude	lb.	1 20	—	1 30
Naphthylamin-di-sulphonic acid	lb.	1 00	—	1 10
Nitro naphthaline	lb.	.45	—	.50
Nitro toluol	lb.	.50	—	.55
Ortho-amidophenol	lb.		—	
Ortho-dichlor-benzol	lb.	.15	—	.18
Ortho-toluidine	lb.	1 25	—	1 30
Ortho-nitro-toluol	lb.	.75	—	1 00
Para-amidophenol, base	lb.	3 50	—	3 75
Para-amido-phenol, H. Cl	lb.	4 00	—	5 00
Para-dichlor-benzol	lb.	.12	—	.15
Paranitraniline	lb.	1 25	—	1 30
Para-nitro-toluol	lb.	1 50	—	1 60
Paraphenylenediamine (base)	lb.	3 00	—	3 25
Para toluidine	lb.	2 25	—	2 50
Phthalic acid anhydride	lb.	3 50	—	4 00
Phenol, U. S. P.	lb.	.52	—	.54
Resorcin, technical	lb.	5 75	—	6 00
Resorcin, pure	lb.	8 50	—	9 00
Salicylic acid	lb.	.95	—	1 00
Salol	lb.	1 90	—	2 00
Sulphanilic acid, crude	lb.	.32	—	.35
Tolidin	lb.	2 25	—	2 50
Toluidine-mixture	lb.	.75	—	.85

Petroleum Oils

(Crude (at the Wells))

Pennsylvania	bbl.	4 00	—	
Corning, Ohio	bbl.	2 85	—	
Somerset, Ky	bbl.	2 50	—	
Wooster, Ohio	bbl.	2 68	—	
Indiana	bbl.	2 28	—	
Illinois	bbl.	2 42	—	
Oklahoma and Kansas	bbl.	2 25	—	
Caddo, La., light	bbl.	2 25	—	
Coriscana, Tex., light	bbl.	2 25	—	
California	bbl.	.98	—	1 32
Gulf Coast	bbl.	1 35	—	

(Fuel Oil)

New York	gal.	11	—	
Pittsburgh	gal.	07½	—	10
Oklahoma-Kansa	bbl.	1 05	—	2 75
Texas	bbl.	1 50	—	1 90
Los Angeles	bbl.	1 52	—	
San Francisco	bbl.	1 45	—	

(Gasoline (Wholesale))

New York	gal.	24	—	
Boston	gal.	25	—	
Pittsburgh	gal.	27	—	
Chicago	gal.	21	—	
Oklahoma	gal.	25	—	
San Francisco	gal.	20	—	

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	21	—	22
Cylinder, light	gal.	36	—	38
Cylinder, dark	gal.	35	—	36
Paraffine, high viscosity	gal	40	—	41
Paraffine, 903 sp. gr	gal.	36	—	38
Paraffine, 865 sp. gr	gal.	26	—	28

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	44	—	
Pine oil, steam distillated, sp. gr. 0.925-0.940	gal.	53	—	
Pine oil, destructively distilled	gal.	49	—	53
Pine-tar oil, sp. gr., 1.025-1.035	gal.	35	—	
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	40	—	
Pine oil, light, sp. gr. 0.950, tank-cars, f. o. b. works	gal.	37	—	
Pine oil, heavy, sp. gr. 1.025, tank-cars, f. o. b. works	gal.	26	—	
Pine tar, thin, spo. gr. 1.060-1.080	gal.	30	—	
Turpentine, crude, spo. gr. 0.980-1.000	gal.	40	—	
Hardwood oil, f. o. b. Michigan, sp. gr. 0.960-0.990	gal.	19	—	
Hardwood oil, f. o. b. Michigan, sp. gr. 1.06-1.08	gal.	19	—	
Wood creosote, ref. f. o. b. Florida	gal.	31	—	

Vegetable and Other Oils

China wood oil	lb.	25½	—	
Cottonseed oil, crude	lb.	17	—	18
Linseed oil, raw, cars	gal.	1 54	—	1 55
Peanut oil, crude	gal.	1 37	—	
Rosin oil, first run	gal	41	—	
Rosin oil, fourth run	gal.	.58	—	
Soya bean oil, Manchuria	lb.	.19	—	.19½
Turpentine, spirits	gal	.41	—	

Miscellaneous Materials

Barytes, floated, white, foreign	ton	Nominal		
Barytes, floated, white, domestic	ton	30 00	—	36 00
Beeswax, white, pure	lb.	.56	—	.64
Casein	lb.	.22	—	.30
Chalk, light, precipitated, English	lb		—	
China clay, imported, lump	ton	17 50	—	36 00
China clay, domestic, lump	ton	12 50	—	20 00
Feldspar	ton	8 00	—	12 00
Fluorspar, gravel, f. o. b. mines	ton	33 00	—	35 00
Fuller's earth, powdered	100 lb	1 00	—	1 50
Graphite, flake	lb.	.16	—	.18
Ozokerite, crude, brown	lb.	.65	—	.75
Ozokerite, American, refined, white	lb.	.75	—	1 00
Red lead, dry, carloads	lb.	.10	—	.11½
Rosin, 280 lb	bbl.	6 15	—	
Soapstone	ton	10 00	—	12 50
Talc, American, white	ton	15 00	—	22 00
White lead, dry	lb.	.09	—	.10

Refractories, Etc.

(F. O. B. Works)

Chrome brick	net ton	Nominal		
Chrome cement, German	net ton	Nominal		
Clay brick, 1st quality fire clay	per 1000	50 00	—	55 00
Clay brick, second quality	per 1000	35 00	—	40 00
Magnesite, raw	ton	30 00	—	35 00
Magnesite, calcined	ton	32 00	—	35 00
Magnesite, Grecian, dead burned	net ton	85 00	—	90 00
Magnesia brick, German, 9x4½x2½	net ton	135 00	—	140 00
Silica brick	per 1000	50 00	—	60 00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent., carload, f. o. b. Niagara Falls, N. Y.	ton	200 00		
Ferrocerium	oz.	20 00		
Ferrochromium, per lb. of Cr	lb.	50		
Ferromanganese, domestic, 70 per cent.	ton	250 00		
Ferromanganese, English	ton	325 00		
Ferromolybdenum, per lb. of Mo	lb.	2 00		
Ferrophosphorus, 75 per cent., f. o. b., N. Y.	ton			
Ferrosilicon, 50 per cent.	ton	180 00	—	190 00
Ferrosilicon, 50 per cent.	ton	165 00	—	175 00
Ferrotungsten, 75-85 per cent.	lb.	2 25	—	2 35
Ferrouranium, f. o. b.	lb.	7 00	—	7 50
Ferrovanadium, f. o. b.	lb.	4 00	—	5 00

Ores and Semi-finished Products

Antimony, 62 per cent.	lb.	1 60	—	1 70
Chrome ore, 42 per cent.	ton	1 40	—	1 60
Chrome ore, 48 per cent.	ton	1 90	—	
Manganese, 48 per cent.	lb.	1 2	—	
Manganese ore	ton	80 00	—	100 00
Molybdenite, per lb. of Mo	lb.	1 85	—	
Tungsten, Scheelite, per unit	unit	24 50	—	
Tungsten, Wolframite	unit	24 00	—	
Uranium oxide	lb.	3 25	—	3 60
Vanadium pentoxide	lb.	10 50	—	
Pyrites, foreign	unit	17	—	17½
Pyrites, domestic	unit	2	—	

INDUSTRIAL

Financial, Construction and Manufacturers' News

New Companies

The ALUMINUM ROLLING MILLS COMPANY, Cleveland, O. Capital, $1,000,000. To operate a local plant for the manufacture of steel, etc. Incorporators: F. H. Pelton and George B. Folk, Cleveland.

The ANNA LEE MINING COMPANY, Carthage, Mo. Capital, $75,000. To mine for lead and zinc. Incorporators: J. C. Wyatt, C. B. Pollard, R. A. Mooneyham, all of Carthage; C. Vernon, and W. C. Lucas, Kansas City.

The AUBUCHON SILICA MINING & MILLING COMPANY, St. Louis, Mo. Capital, $100,000. To mine for silica. Incorporators: Carl E. Aubuchon, Charles Spier, and Thomas B. Aubuchon.

The BOND CHEMICAL COMPANY, Camden, N. J. Capital, $125,000. To engage in the manufacture of chemicals and allied products. Incorporators: John J. Finney, Joseph Mallon, and F. M. Wick, Camden.

The CHICAGO COKE & CHEMICAL COMPANY, Portland, Me. Capital, $100,000. To operate a plant for the manufacture of chemicals, coke, iron, etc. Incorporators: P. B. Drew, C. G. Trott, and D. F. Drew, Portland.

The COLONIAL ANILINE WORKS, Monticello, N. Y. Capital, $10,000. To engage in the manufacture of dyestuffs and chemicals. Incorporators: P. S. Glickstein, W. and C. Lowenthal, 424 Caton Avenue, Brooklyn.

The CO-OPERATIVE FERTILIZER COMPANY, Miami, Fla. Capital, $30,000. To manufacture fertilizers. Incorporators: J. Petersen, C. M. Brown, Sr., and Charles D. Rowe.

The CORNWALL PAPER MANUFACTURING COMPANY, Cornwall, N. Y. Capital, $50,000. To manufacture paper and paper products. Incorporators: A. G. Lutz, F. B. Oldham, and L. Hecht, 403 Avenue C, Brooklyn, N. Y.

The DUNCAN LEAD & ZINC COMPANY, Duncan, Okla. Capital, $200,000. To engage in a general lead and zinc mining business. Incorporators: W. E. Williams, J. H. Goodnight, and W. M. Lockett, Duncan.

The EARLE CHEMICAL COMPANY, Wheeling, W. Va. Capital, $15,000. To engage in the manufacture of chemicals and kindred specialties. Incorporators: R. I. Runner, E. H. Draker, Eugene Hill, Raymond Sypher, and C. Rader, Wheeling.

The FOUNDRY EQUIPMENT & METALS COMPANY, Covington, Ky. Capital, $10,000. To operate a local foundry. Incorporators: L. A. and A. E. Clifton, and Frank X. Bertsch, Covington.

The HAMILTON ABRASIVE COMPANY, Westfield, Mass. Capital, $50,000. To manufacture abrasive materials of various kinds. Incorporators: F. D. Hamilton, Louis M. Fuller, and H. B. Putnam, Westfield.

The HARVEY CHEMICAL COMPANY, Hoboken, N. J. Capital, $50,000. To engage in the manufacture of chemicals and allied products. Incorporators: Jacob J. Harvey, East Orange; O. C. Harvey, Orange, and Harry B. Harvey, Newark.

The INTERSTATE LEAD & ZINC MINING COMPANY, Vinita, Okla. Capital, $40,000. To mine for lead and zinc. Incorporators: L. G. Sims, L. M. Linebaugh, Vinita, and S. P. Strong, Dallas, Tex.

J. F. LINBERG COMPANY, Inc., Jamestown, N. Y. Capital, $50,000. To manufacture chemicals and dyestuffs, etc. Incorporators: R. M. Bates, and E. J. and J. F. Linberg, all of Jamestown.

The LONE STAR LEAD & ZINC COMPANY, Miami, Okla. Capital, $200,000. To engage in a general lead and zinc mining business. Incorporators: B. C. Clark, Purcell; C. A. Clark, Oklahoma City; and R. I. Tibbs, Maypearl, Texas.

The LUDLUM STEEL COMPANY, Detroit, Mich. Nominal capital, $5,000. To manufacture steel and iron products. Incorporators: Lester P. Dodd, Norman J. Miller, and A. E. Perrin.

McCAFFREY & COMPANY, Inc., Philadelphia, Pa. Capital, $10,000. To engage in the manufacture of paper, paper boxes, etc. Joseph J. McCaffrey is the principal incorporator.

The MAXWELL PAINT COMPANY, Philadelphia, Pa. Capital, $10,000. To manufacture paints, etc. Morris Liveright is treasurer.

The MAYER & CLARKSON COMPANY, Buffalo, N. Y. Capital, $50,000. To manufacture iron and steel mill, shop, and foundry supplies. Incorporators: Alfred L. Mayer, A. A. Mayer, and C. B. Clarkson.

The MORRIS COUNTY CHEMICAL WORKS, Butler, N. J. Capital, $100,000. To operate a plant for the manufacture of chemicals, etc. Incorporators: John A. Marszalek, Thomas L. Sexsmith, William Joyce, and Walter A. Clark, Butler.

The NATIONAL BASIC FERTILIZER COMPANY, Birmingham, Ala. Capital, $137,000. To manufacture basic phosphate fertilizer. Incorporators: C. E. Elgin, Searles, Ala.; J. W. Lowman, Albany, and W. S. Oglesby, Searles, Ala.

The NEW LONDON CHEMICAL COMPANY, New London, Conn. Capital, $50,000. To manufacture chemicals and allied products. Incorporators: Bert W. Flanders, Ira M. Comstock, and H. E. Harris, New London.

The PANTO LEAD & ZINC COMPANY, Ada, Okla. Capital, $100,000. To mine for lead and zinc, etc. Incorporators: J. G. Witherspoon, Harmon Ebey, and Frank Jackson, Ada.

The PHILADELPHIA ELECTRIC STEEL CORPORATION, Wilmington, Del. Capital, $70,000. To manufacture electric steel and allied products. Incorporators: F. A. Armstrong, M. M. Clancy, and C. L. Rimlinger, Wilmington.

The PREMIUM ZINC MINING COMPANY, Oklahoma City, Okla. Capital, $75,000. To engage in the development of zinc properties. R. L. Ritchie is the principal incorporator.

The CHARLES H. PRIME COMPANY, Inc., New York. Capital, $50,000. To manufacture strawboard, boxboard, cardboard, etc. Incorporators: P. H. Smeallie, C. H. Prime, and J. K. Voorhees, 200 Fifth Avenue.

The PYROTOL CHEMICAL COMPANY, Beaumont, Tex. Capital $35,000. To manufacture chemicals and allied products. Incorporators: Bruce Richardson, S. Gordon, E. J. Goodier, and A. H. Safir.

The RED RIVER VALLEY LEAD & ZINC COMPANY, Durant, Okla. Capital, $50,000. To engage in the development of lead and zinc lands. Incorporators: George B. Morris, G. Thompson, Durant, and J. H. Holland, Achille.

The ROBAX CHEMICAL COMPANY, Dover, Del. Capital, $100,000. To manufacture chemicals and kindred specialties. Incorporators: Cornelius A. Cole, Hackensack, N. J.; Arthur R. Oakley, Pearl River, N. Y.; and Paul E. Britsch, Brooklyn, N. Y.

JACOB RUBIN & SON, New York. Capital, $75,000. To manufacture plate and window glass. Incorporators: J., H. H. and L. Rubin, 1516 Fifty-fourth Street, Brooklyn.

The RUBY JACK MINING COMPANY, Harrison, Ark. Capital, $200,000. To mine for lead and zinc. Incorporators: C. C. Wolf, O. L. Perry, D. M. Ormand, Harrison.

The SEABOARD BRASS FOUNDRIES, Inc., Brooklyn, N. Y. Capital, $52,500. To operate brass and other foundries. Incorporators: Donald Hayes, 5 Hanson Place, and C. Holter, 173 Lenox Road, Brooklyn.

The UNITED STATES PAPER MILLS, Inc., Chambersburg, Pa. Capital, $30,000. To operate mills for the manufacture of paper. Milton Long is the principal incorporator.

The VOLCO LEAD & ZINC COMPANY, Oklahoma City, Okla. Capital, $200,000. To engage in the development of lead and zinc properties. Incorporators: O. R. Jeter, Brinkman; N. U. Stout, Snyder, and S. M. Jones, Headrick, Okla.

The WESTERN CHEMICAL PRODUCTS COMPANY, Vernon, Cal. Capital, $25,000. To manufacture chemicals and allied products. Incorporators: G. W. Marchand, Long Beach; W. T. Moore, Long Beach, and T. C. Yeager, Canton, Mo.

Construction and Operation

Alabama

BIRMINGHAM.—Announcement has been made by the Tennessee Coal, Iron & Railroad Company that extensive improvements and additions will be made at its Fairfield byproduct coking plant which will double the present capacity. The work includes the construction of two additional batteries of seventy-seven ovens each, or a total of 154 ovens, together with complete byproduct recovery plants. The ovens will be of the Koppers type. It is said that the project will involve an expenditure of about $2,000,000. George G. Crawford is president.

LOCK TWELVE.—In addition to the expenditure of $30,000,000 planned by the Government for the construction of a nitrate plant at Muscle Shoals, it is understood that an expenditure of $500,000,000 is planned for the erection of additional nitrate plants, one of these to be located near Lock Twelve on Warrior River.

Arizona

TUCSON.—Alfred Roos, of Tucson, and associates, are planning for the immediate construction of a large new plant for the handling of wulfenite concentrates.

MIAMI.—The Miami Copper Company is considering plans for the construction of a new addition to its plant to increase the present capacity. A 6,000-ton mill is now in operation.

California

BISHOP.—The Round Valley Tungsten Company is planning for extensive development work at the camp at the Pine Creek tungsten claims recently acquired, including the installation of two new Marcy mills having a combined capacity of 150 tons daily.

BOLINAS.—The Chetco Mining Company has commenced extensive development at its copper properties in Marin County near Bolinas, and operations have been inaugurated in a new 40-ton mill, comprising crusher, Hendy ball-mill, and Overstrom concentrator.

CRESCENT MILLS.—The Juneday Mining & Milling Company has completed the installation of new machinery at its properties in Plumas County, and is planning for the construction of a new 50-ton mill.

PITTSBURG.—The Columbia Steel Company is making rapid progress in the construction of a new addition to its plant to increase the present capacity by about fifty per cent. Immediately upon completion of the structure, the company will commence the installation of two 30-ton and one 10-ton traveling cranes and a new 15-ton locomotive crane. Power for operation will be supplied by the Pacific Gas & Electric Company.

SAN FERNANDO.—Plans have been filed by the San Fernando Canning Company for the construction of a new canning works, about 100 x 475 feet. The structure, contract for which has been awarded, is estimated to cost $25,000, and the equipment to be installed will cost $40,000.

Colorado

CRIPPLE CREEK.—The Camp Bird Mining, Leasing & Power Company has had plans prepared for the construction of a large new ore-house at its properties.

NEDERLAND.—The La Plaisance Mining & Milling Company, recently incorporated, is planning for extensive development work at the La Plaisance gold and silver mine, to be operated in connection with the New England mine. E. V. Grant, F. A. Fair, and Alfred Dawson are interested in the company.

PUEBLO.—Negotiations have been completed by the Norcross Chemical Company for the leasing of the plant formerly occupied by the Table Queen Baking Company on South Union Avenue, and the company is planning to commence work on alterations and improvements to utilize the plant as a chemical manufacturing works and laboratory. New machinery will be installed immediately upon completion of these improvements, the new plant to be devoted to the manufacture of bismuth compounds, copper oxide, and iodoform. The company has completed the construction of a large new manufacturing plant near Stone City, which will manufacture various acids and explosives. W. E. Young is vice-president.

SILVERTON.—The D., L. & W. Mining and Reduction Company is engaged in extensive development work at its properties, and plans are under consideration for the construction of a new mill along the Animas River. H. M. Kingsley is manager.

Connectnicut

BRISTOL.—The plant of the Munroe & Muzzy Pen Company, located in the Edgewood district, near Bristol, was recently partially destroyed by fire, with loss estimated at $50,000.

STAMFORD.—Baer Brothers, Canal Street, manufacturers of paints, etc., have commenced the reconstruction of the portion of its plant recently destroyed by fire, with loss estimated at $100,000. The company is planning to increase the former capacity of the plant.

Idaho

MULLAN.—The Copper King Mining Company is considering plans for the construction of a new 200-ton mill at its plant. H. W. Ingalls is manager.

SAGLE.—The Armstead Mines Company, which operates on Pend Creille Lake, has made an appropriation of $200,000 to provide for the erection of a new 100-ton mill and other development work. Plans have been prepared by O. H. Hofstrand, Salt Lake City, Utah. H. H. Armstead is president.

Illinois

CHICAGO.—The Interstate Iron & Steel Company, Seventy-eighth Street and South Chicago Avenue, has had plans prepared for the construction of a new one-story addition to its plant.

EAST ST. LOUIS.—The Lubrite Refining Company, Tulsa, Okla., has had plans prepared for the construction of a large new local plant on property recently acquired near Twentieth Street and the Alton & Southern Railroad, comprising about twenty-five acres. The plant, which will be devoted to the production of airplane lubricants, will have an initial capacity of 1,000 barrels daily, ultimately to be increased to 5,000 barrels. W. S. Strickler is president.

LA SALLE.—The Valley Chemical Company is rushing to completion the construction of a large new addition to its plant. Immediately upon completion of the structure, which it is estimated will be within the next three months, the company will install the necessary furnaces and machinery for operation.

Indiana

EVANSVILLE.—Plans have been completed by the Hercules Gas Engine Company for the construction of a large new addition to its plant, the structure to be one-story, about 175 x 450 ton. It is estimated that the new building will cost about $150,000.

TERRE HAUTE.—Plans are under consideration by the Rott Glass Company for the construction of a new addition to its plant.

Iowa

BELMONT.—The Valley Sugar Company, recently organized, has acquired the Elder property comprising about 270 acres and is planning for the construction of a large new plant for the production of beet sugar.

CEDAR RAPIDS.—Plans are under consideration by the Viking Pump Company, manufacturer of pumping machinery and equipment for the construction of a new addition to its plant, about 35 x 125 feet. The structure is estimated to cost $20,000.

Kansas

WICHITA.—The Lucky Eight Oil & Gas Company is planning for the construction of a large new oil refinery on a site now under consideration at Eldorado to have an initial capacity of 2,000 barrels daily. It is expected that the new plant will be ready for operation by August 1. F. L. Wright is president.

Kentucky

LOUISVILLE.—The Louisville Fertilizer Company, operating a mixing plant for the production of commercial fertilizer, is said to be considering the construction of a large plant on property adjoining its present works, the new factory to be devoted to the manufacture of nitrates.

Louisiana

LAKE CHARLES.—The United States Government has awarded a contract for the construction of a large new local oil refinery and research building to the American Construction Company, Houston, Tex., and work will commence at once.

Maryland

CUMBERLAND.—F. Brooke Whiting and J. Blaine White are arranging for the organization of a new company to operate the plant formerly occupied by the Eastern Glass Works, at South Cumberland. The works comprise five acres and extensive alterations and improvements will be made. The plant will be devoted to the manufacture of high grade glassware and it is expected to be completed within three months, giving employment to about 100 hands for initial operations.

Michigan

ALMA.—The R. & P. Tractor Company, recently incorporated, is planning for the immediate establishment of a local plant. F. W. Ruggles is president.

IRON MOUNTAIN.—The Aragon Mining Company is planning for the immediate operation of the Oliver properties, Norway, near Iron Mountain. New mining machinery will be installed immediately the entire plant to be electrically operated.

WAYNE.—The Harroun Motors Corporation is considering plans for the construction of a new one-story addition to its plant. It is said that the structure, which is estimated to cost $150,000, will be used for the manufacture of shells for the Government.

Mississippi

CHARLESTON.—The Lamb-Fish Lumber Company has recently awarded a contract to the Unit Construction, St. Louis, Mo., for the construction of a large plant for the extraction of denatured alcohol and acetone from mill waste. It is said the works will cost about $1,000,000.

Missouri

ST. LOUIS.—Plans are under consideration by the Johnston Tin Foil & Metal Company, South Broadway, for the construction of a new two-story plant about 50 x 100 feet. The works are estimated to cost about $50,000.

ST. LOUIS.—The St. Louis Coke & Chemical Company is having plans prepared for the construction of its proposed new plant at Granite City, Ill., estimated to cost $5,000,000. Included in the plans is the erection of a byproduct coke oven and two blast furnaces. This company is a subsidiary of the American Coke & Chemical Company.

Montana

EAST HELENA.—The Economy Mining Company is making rapid progress in the construction of a new 75-ton concentrating mill at the Economy mine, and extensive additional development work is contemplated.

Nevada

ELKO.—The Standard Oil Shale Company, which was reorganized at Salt Lake City, Utah, with a capital of $1,250,000, is planning for the construction of a new 100-ton plant for the distillation of oil from shale at its Elko properties. The company has acquired 1000 acres of land near Elko, and 1000 acres near Levan, Juab County, Utah.

New Mexico

HANOVER.—The Republic Mining & Milling Company has plans under consideration for the construction of a new 100-ton concentrating mill.

New Jersey

JERSEY CITY.—The Hudson County Smelting & Refining Works has filed authorization papers to operate a smelting and refining plant at 489 Henderson Street. Jacob Laffer, 161 Pavonia Avenue, Jersey City, head, the company.

KEARNY.—Swift & Company have filed plans for the construction of a new five-story reinforced-concrete rendering plant to be located in the Kearny meadow district. It is said that this will be the largest plant of its kind in the East, the company planning to have a capacity of about 3,000,000 pounds of raw product monthly.

NEWARK.—The Butterworth-Judson Corporation, Avenue R, manufacturer of chemicals, is having plans prepared for the reconstruction of the portion of its plant recently destroyed by fire, with loss estimated at $200,000.

NEWARK.—The International Oxygen Company has taken out a building permit for the construction of a new plant at 796 Frelinghuysen avenue, estimated to cost about $20,000.

ELIZABETH.—The Linden Tanning Company has completed negotiations for the purchase of the tanneries of M. Straus & Sons, located at 42–68 Frelinghuysen Avenue, Newark, consisting of a series of two, three and four-story brick buildings containing approximately 250,000 square feet of floor space. The property was held at $300,000.

PERTH AMBOY.—The American Smelting & Refining Company has had plans prepared for the construction of a new addition to its plant to cost about $75,000.

PERTH AMBOY.—The Roessler & Hasslacher Chemical Company has taken out building permits for the construction of two new additions to its plant. Contracts for the structures have been awarded.

JAMESBURG.—The Texas Refining Company has recently acquired property near Jamesburg as a site for the construction of a new plant for the manufacture of lubricants. Construction work has been commenced on one of the units of the plant, a structure 50 x 50 feet. It is said that the company has received a contract from the Government for 10,000 barrels of grease for auto trucks.

BAYONNE.—The Standard Oil Company of Avenue K, having a frontage of 621 feet on the Kill von Kull, and extending about 800 feet to the National Docks Railroad, for a consideration said to be in the neighborhood of $775,000. It is said the property will be used for extensions.

New York

NEW YORK.—The American Aniline Products Company, 80 Fifth Avenue, has acquired the plant of the United Piece Dye Works, Nyack, N. Y., occupying the entire block fronting on Railroad Avenue, Cedar Hill Avenue, Hudson and Florence Streets. The works comprise a number of brick buildings having a total floor space of about 90,045 square feet, and the property was held at $105,000. The company is planning to use the plant for the manufacture of aniline colors, principally khaki and navy blue, having secured a large contract from the Government.

BROOKLYN.—The Long Island Soap Company has had plans prepared for the construction of a new three-story reinforced-concrete plant, about 50 x 80 feet, at Bridgewater Street and Meeker Avenue. David M. Ach, 1 Madison Avenue, New York, is architect.

FULTON.—The Oswego Pulp & Paper Company, Fulton, has had plans prepared for the construction of a new three-story local plant, to cost about $60,000. Charles Eaton, Watertown, is architect.

Ohio

CLEVELAND.—The Standard Foundry Manufacturing Company has taken out a brick and reinforced-concrete addition to its plant at 2717 East Seventy-fifth Street.

CLEVELAND.—Fire on April 10 following an explosion damaged the plant of the Grabler Manufacturing Company to the extent of approximately $200,000. The company was engaged in the manufacture of hand grenades for the Government.

COLUMBUS.—The Columbus Metal Company, recently incorporated with a capital of $30,000, has inaugurated operations in its new foundry at 459 South Parsons Avenue. The company will engage in the manufacture of castings of all kind.

HAMILTON.—The Beckett & Marquardt Company has taken out a building permit for the construction of a new reinforced-concrete factory building on Mill Road, to cost about $25,000.

YOUNGSTOWN.—The Carnegie Steel Company is preparing plans for the construction of extensive additions to its local plant, including the erection of a large new byproduct coke plant.

YOUNGSTOWN.—The Liberty Steel Company has plans under consideration for the construction of additions to its local plant to increase its present capacity. It is said that the company will make $600,000 of the additions, of which $350,000 will be contributed and $750,000 preferred to provide working capital for the period. At the present time the plant has a capacity of 600 tons of ingots per year, and it is proposed to increase this to 20,000 tons annually.

Oklahoma

POTEAU.—Edgar A. Berry and associates, operating a plant at Okmulgee for the manufacture of window glass, have completed negotiations with the local Chamber of Commerce for the removal of its plant to Poteau. It is estimated that the new works will cost about $50,000 and will give employment to about 125 hands for initial operations.

Pennsylvania

PHILADELPHIA — Fels & Company, Seventy-third and Woodland Avenue, manufacturers of soaps, have had plans prepared for the construction of a new one-story brick addition to their plant, about 65 x 95 feet, at Woodland Avenue and 73rd and Road. Harris & Richards, Drexel Building, Philadelphia, are the architects.

MARCUS HOOK.—The General Chemical Company, 25 Broad Street, New York, has recently awarded a contract for the construction of a new one-story and basement service building, about 100 x 100 feet, at Marcus Hook. The structure is estimated to cost $100,000. The Carleton Company, 151 West Forty-second Street, New York, is the contractor.

NEW CASTLE.—The Grasselli Powder Company, Cleveland, O., has commenced the construction of its new local acid manufacturing plant, which will comprise eight one-story units and a power plant for works operation. It is said that the plant, when completed, will represent an investment of about $1,000,000.

PITTSBURGH.—The Yankee Steel Company of America, recently incorporated under Delaware laws with a capital of $1,000,000, is considering the construction of a large plant near Sharpsville for the manufacture of sheet steel products. Ephraim Truxall is president and general manager.

Rhode Island

PROVIDENCE.—The Standard Oil Company of New York has acquired a large tract of land near its local distributing station, and is said to be planning for the construction of a large new refinery, can factory, and shipbuilding works.

Texas

HOUSTON.—The Prairie Oil & Gas Company has recently acquired property on the Houston Ship Channel, comprising about 400 acres, as a site for the construction of a large new oil refinery. It is said that plans are under consideration for the construction of a pipe line from Cushing, through Ranger, to the ship channel.

QUANAH.—T. Sanford Gibbs is having plans prepared for the construction of a new concentration mill at his copper properties near Quanah.

Utah

GOLD HILL.—The Deep Creek Investment Company is considering the construction of a new local mill for the treatment of low-grade ore. F. W. Ferriss is president.

MARYSVALE.—Rapid progress is being made by the Florence Mining Company in the construction of a new 100-ton mill at its alunite properties. Jacob Young is manager.

Washington

CHEWELAH.—The Northwest Magnesite Company is planning for the installation of new machinery at its plant to provide for increased capacity. The improvement is estimated to cost $150,000.

KELLER.—The Iron Creek Mining Company is planning for the early construction of a new 25-ton mill at its properties.

West Virginia

MORGANTOWN.—The Economy Tumbler Company is planning for the construction of new additions at its glassware manufacturing plant to cost about $175,000.

PARKERSBURG.—The Brown Flint Glass Company, recently incorporated with a capital of $50,000, has completed its organization and is planning for the manufacture of glassware. J. W. Brown, of Vienna, is president.

Wisconsin

CUBA CITY.—The Hercules Mining Company of Wisconsin, recently incorporated with a capital of $100,000, is planning for the construction of a new 100-ton mill at its local properties located near Plattesville. Harry Seemiller is general manager.

Canada

TORONTO, ONTARIO.—Fire recently destroyed a portion of the plant of the Thor Iron Works, foot of Bathurst Street, with total loss estimated at $300,000.

Mexico

CANANEA.—The Calumet-Sonora Mining Company, whose properties are located about four miles from Cananea, has completed the construction of a new 500-ton concentrating plant for the treatment of ore from the Catalina mine.

Trade Notes

The ZAREMBA COMPANY, of Buffalo, has moved its offices to the Niagara Life Insurance Building, corner of Franklin and Mohawk Streets.

The YARNALL-WARING COMPANY, of Philadelphia, has decided to group its several power-plant accessory products under the family name of "Yarway."

The HUFF ELECTROSTATIC SEPARATOR COMPANY, owners and manufacturers of the electrostatic process of ore concentration, have opened an office at 120 Broadway, New York, for consultation regarding ore dressing problems, especially the dry concentration of ores and the separation of valuable minerals from others which are commercially detrimental. The office will be in charge of A. L. Sweetser.

The EASTON CAR & CONSTRUCTION COMPANY, Easton, Pa., announce the opening of a new Branch Office in Washington, D. C., the address being 225 Kellogg Building, 1422 F. Street, N. W.

SWEDISH BEATER FILLING NOW MANUFACTURED IN THE UNITED STATES.—Helin's beater filling, which has met with much success in Europe and particularly in Sweden, is now being manufactured and marketed in the United States by the Fibre Making Processes, Inc., 440 So. Dearborn Street, Chicago, Ill. This filling is a cast iron composition, combining a structure of basalt lava with strength and durability. The manufacturers claim that compared with steel knives this filling doubles the capacity with about the same power consumption.

NATIONAL ANILINE DIRECTORS.—At the annual meeting of the shareholders of the National Aniline and Chemical Co., Inc., held at 244 Madison Avenue, New York City, on February 18th, 1918, the following board of directors was elected:

Dr. Wm. Beckers, New York City.
H. H. S. Handy, Syracuse.
Dr. L. C. Jones, Syracuse.
Clinton S. Lutkins, New York City.
Wm. J. Matheson, New York City.
Eugene Meyer, Jr., New York City.
W. N. McIlravy, New York City.
T. M. Rianhard, New York City.
J. F. Schoellkopf, Buffalo.
C. F. Hugo Schoellkopf, Buffalo.
J. F. Schoellkopf, President, Buffalo.
Robert Alfred Shaw, New York City.
L. Frank Stone, New York City.
Dr. R. C. Taggersell, Buffalo.
Orlando F. Weber, New York City.
Henry Wigglesworth, New York.

The new names appearing in the above are Dr. Taggersell, chief chemist of the manufacturing department at Buffalo; Dr. Jones, chief chemist of the Semet-Solvay Company; Mr. C. S. Lutkins, Secretary of the General Chemical Company; Mr. Orlando F. Weber, now associated with the War Industries Board at Washington.

The house of PHILLIPPE BERGER, Paris, France, announces that it will send one of its engineers to the United States to be here during April and May. He will have full buying authority for machinery and raw materials and will consider propositions for the establishing of industries in France. Communications should be sent to M. León Belge, Hotel Biltmore, New York.

MARDEN, ORTH & HASTINGS CORPORATION, 61 Broadway, New York, has acquired the control of the Buttercup Oil & Car Company, of Louisville, Kentucky. Buttercup Oil & Car Company is reported to be one of the largest producers of edible oils in the United States, and it is understood that they will continue the refining of peanut, cocoanut and cotton seed oils, and other edible oils will be added to their production list.

SCHUTTE & KOERTING CO., TRANSFERRED.—At a meeting held on February 23, 1918. The stock of the company was transferred to the alien property custodian of the United States and at his instance the Board of Directors was reconstructed as follows: E. Pusey Passmore, Governor of the Federal Reserve Bank, Philadelphia; Ralph J. Baker, Asst. Gen'l Counsel of the alien property custodian; D. W. Hildredth, treasurer of Schutte & Koerting Co.; T. H. Johnston, Schutte & Koerting Co.; Chas. S. Calwell, president Corn Exchange National Bank, Philadelphia. The new board elected the following officers: Chas. S. Calwell, president; D. W. Hildreth, treasurer; Ralph J. Baker, secretary.

This ensures the active continuation of the business in all its lines.

THE SURFACE COMBUSTION CO. has changed its address from Long Island City to 366-368 Gerard Ave, Bronx, N. Y., where increased space and new equipment has been provided.

The PERMUTIT CO., manufacturers of water softening and water rectification apparatus, and for several years past located at 30 E. 42nd Street, New York, announces its removal on March 15th to 440 Fourth Ave., New York.

MONSANTO AND COMMERCIAL ACID CO. CONSOLIDATE. — The Monsanto Chemical Company of St. Louis has purchased the Commercial Acid Company of East St. Louis for a consideration in excess of $2,000,000. Announcement to this effect was made recently by John F. Queeny, president of the Monsanto Company.

The Commercial Acid Company's plant is on a tract of 140 acres, and is one of East St. Louis' largest industrial institutions. The Monsanto Company is one of the leading manufacturers of medicinal chemicals in this country, its plant occupies two blocks in South St. Louis. The new corporation will be capitalized at about $5,000,000.

DYE PATENT LICENSES FOR DU PONT.—Recent applications to the Federal Trade Commission for licenses to manufacture under German-controlled patents under the "trading-with-the-enemy" act include several from E. I. du Pont de Nemours & Co. as follows: Applications covering patent No. 868,294, on a process of producing phenylglycin and its homologues, held by the Farbwerke Hoechst and patent No. 680,395, on a process of making indoxyl derivatives, held by the Roessler interests, of Frankfort-am-Main; No. 818,992, anthracene dye and process of making, patent of Bally & Isler; No. 787,859, anthracene compound and process of making, patent of Scholl & Bally; No. 1,003,268, anthracene dye and process of making, patent of Just & Wolf; No. 796,393, anthracene coloring matter and process of producing, patent of Bally; No. 753,659, anthracene derivative and process of making, patent of Rene Bohn; No. 739,145, anthracene dye, patent of Bohn; No. 1,055,701, pigment and process of making, patent of Bohn; No. 724,789, blue dye and process of making, patent of Bohn; No. 1,063,119 producing aminoanthraquinone and derivatives, patent of Rampini; No. 906,367, anthracene dye and process of making, patent of Bally & Wolff; No. 711,377, solid alkaline hydrosulphites and process of making, patent of Bazlen; No. 961,612, anthracene compound and process of making, patent of Isler & Wolff; No. 931,958, sulphur dye and process of making, patent of Haas; No. 795,755, process of making stable dry hydrosulphites, patent of Bazlen.

All of the last fourteen patents enumerated above were held on assignment by the Badische Anilin und Soda Fabrik, of Ludwigshafen am Rhein.

NEW CHEMICAL COMPANIES organized during January had capital of eleven million dollars compored with seven million dollars for such organizations in December and less than four million dollars for those formed in January a year ago. Capital invested in chemical companies for manufacture of chemicals, drugs and dyes in this country since the war began now stands at three hundred and thirty-nine million dollars.

Manufacturers' Catalogs

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, East Pittsburgh, Pa., has issued catalog 8-E, describing Westinghouse industrial heating apparatus.

THE CUTLER-HAMMER MANUFACTURING COMPANY, Milwaukee, Wis., has issued two small circulars, one on the "C-H electric space heater unit" and the other on the "C-H electric air heaters." An 8-page booklet has also been issued describing the Thomas meter for measuring gases and air in large quantities.

CENTRAL SCIENTIFIC COMPANY, Chicago, Ill., has issued circulars describing De Khotinsky constant temperature heating appliances and Cenco direct current meters.

SARCO COMPANY, INC., New York, has issued a folder describing Sarco metallic gasket.

ELECTRIC MACHINERY COMPANY, Minneapolis, Minn., has issued Bulletin 176 describing vertical type alternators directly connected to waterwheels.

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Keep Our Young Men in College

OUR country is confronted with a serious menace to her future welfare through the patriotic response of her young college men to the call for military service. When the war began in 1914 there was a large volunteer movement among students from France and England, to such an extent, indeed, that England later found it necessary to recall from France her technically trained young men. France shortly discovered that her own schools were being deserted, and saw the necessity of recruiting students to furnish a supply of engineers and technologists for the future. With this experience before us, our educators were prepared to sound the necessary warning when the United States entered the war, and almost from the beginning of our participation we have made special efforts to keep young men in college, particularly those who were studying scientific and engineering courses.

More recent data on the situation have been made public through an article by Huber William Hurt in a recent issue of *School and Society*, wherein it is shown that thirty educational institutions in the United States have 26,000 fewer students than they had last school year. The total loss for the higher institutions of learning is estimated at 68,500, which is the number of vacancies that ought to be filled if our colleges and universities are to render full service to the country.

We conceive it to be the duty of engineers everywhere to take definite steps to see that young men now in college are shown the necessity of pursuing their work to the end, and that young men eligible for college training are urged and even assisted to attend a nearby college. There are dozens of ways for a young man to get through college if the spirit wills, and assistance may range from showing how the trick may be turned, to actual financial support during the period of instruction. Here is an opportunity for real service which engineers should not neglect.

Something Usually Lacking in Annual Reports

IT IS said that when the late Abram S. Hewitt was invited to join the board of the United States Steel Corporation at the time it was organized, he refused to do so unless the directors agreed to take the public into their confidence and tell in cold print everything that was done. He insisted that details be given which theretofore were held impossible to disclose, lest competitors learn too much. The argument lasted until late at night, the old ex-mayor holding that the concern was big enough to stand it; that the temper of the times demanded that all the facts be told; that whatever the corporation did that was right it could be proud of and

that whatever it did that was wrong would be found out anyway. He carried his point and to this day men of good-will have not regretted it. The Steel Corporation was one of the pioneers in telling stockholders and the public the things they should know but did not expect to learn. Things both favorable and unfavorable are told with splendid frankness.

The peculiarity—and we might almost say the trouble—with doing one good thing is that it is expected to lead to another, and then to another, and so on without ceasing. It is a feature of the *mores*, of the folkways, of public opinion, that if we blaze a trail of merit of any sort we are expected not only to continue in the path of righteousness, but to take the lead in other respects—all for the public good. One of the first things we learn in childhood is that obedience to parental discipline does not grant exemptions, even though other children persevere in naughtiness.

Now that publicity in the administration of affairs, and about bulk and tonnages, and things not done and things done, and building operations, and costs as well as profits, has been made in their annual reports, we conform to custom and cry for more. We want to see publicity in regard to the administration of materials and to learn about the progress of research from year to year. We are aware that the subject is delicate, that it would be indiscreet to reveal the things hoped for or that are of promise in laboratories or that have reached a semi-commercial scale. It would not be expedient to tell of strategems in manufacture for competitors to imitate. Dividends are, after all, the basis of industry and they must not be neglected. But this is just what we are coming around to: One of the most important features desired of dividends is that they bid fair to continue, and the best way to provide for future dividends is to keep ahead of the game, while the way to keep ahead of the game is by research.

Dr. Mees said the other night at a meeting of the Society of Chemical Industry at the Chemists' Club, that he had found both in England and America about the same cost for building and maintaining research laboratories before the war. He said that $3500 per man to be employed was approximately the cost to build and equip an industrial research laboratory designed for one establishment in one industry, and that the annual maintenance expenses were about the same. Thus if a corporation that had such a laboratory established were to state in its annual report that $35,000 had been expended from its research fund, it would have been fair guessing up to 1915 that there had been about the value of ten men engaged in this kind of work. Of course, it would only be guessing, and it would give no intimation of the merits or the results of the effort. We offer it merely as an alleged measuring stick with no guarantees whatever, beyond the intimation that Dr. Mees has done excellent work in the Eastman laboratory at Rochester, and that he speaks with large experience.

We have no desire to demand of corporations details of their business which it would be unwise to publish. We merely point out that all information on the subject of research is usually suppressed, which we think a mistake. We know, for instance, that the Steel Corporation is diligent in this respect, which reassures us as stockholders; but we learn nothing of it in their annual report.

It is surprising how rapidly the public mind changes. A few years ago the mere mention of a chemical expression was regarded as impolite because nobody reasonable was supposed to know what it meant—and chemistry was held to be made in Germany anyway! Now the question is constantly asked whether we are scientific enough to compete with European countries after the war. The anxiety is less serious in regard to the steel and certain non-ferrous metal industries than it is concerning those which are regarded as more specifically chemical; but it is well to remember that even in variety of special steels the Germans were eminent before the war.

Slowly the fact is dawning upon the public consciousness that in nearly every great industry somebody is working away all the time to find improvement or economy or variety, either in this country or somewhere else. Wherever sound research is carried on the chances are much greater that improvements will be discovered and developed. In one sense, research is going hunting; in another it may be regarded as a modified form of insurance towards future benefit, and it is fair to say that manufacturing organizations that do not engage in it, lack this insurance. They not only lack this insurance but they lack something else; for wherever research is carried on intelligently and with understanding and with a wholesome belief in it, the entire organization becomes alive with the consciousness that improvements are sought. It sharpens the eyes of the whole force and it drives away the monotony of work. Therefore we think it a good thing to tell something in annual reports of the attitude of the administration of great industrial establishments toward this subject; to give at least the encouraging information, if the facts bear it out, that research is in progress.

Of course the rule-of-thumb people are always anxious to prove that they are scientific, science having come into fashion of late. If anything is said of research by the real leaders who engage in it, the rule-of-thumb people will follow the lead and, as likely as not, issue what is sometimes called "blurbs" on their control laboratories in the hope that a credulous public will believe them to be maintaining institutes of research. This will not mislead the technical press. The very ignorance of technical matters within boards of directors about which we have frequently complained is likely to show itself in this respect. But if those who engage in genuine research can be induced to tell something of the measure of their activities in this great field, it may give the less progressive concerns enough of a jolt to make them see a light—which would be a great benefit to American industry.

Iron and Steel Production Rates

IN January and February pig iron was produced in the United States at an average rate below 30,000,000 tons a year. Since April 1 the rate has averaged well above 40,000,000 tons. A favorite estimate of blast-furnace capacity now existing is 43,000,000 tons, and it is quite possible that pig iron will be produced at such a rate in the near future. The controlling factor has been coke. Estimates of the steel ingot capacity range from 47,000,000 to 50,000,000 tons, but from the pres-

ent alignment it seems improbable that if pig iron production reaches a rate of 43,000,000 tons ingot production will reach a rate of 47,000,000 tons.

These and related facts embody two problems: (1) There was something radically wrong with coke production, movement and utilization last winter, and a recurrence of the conditions next winter must be avoided. (2) There is room for further ingenuity on the part of steel works managers in making bricks without straw, or in other words open-hearth steel with a scrap supply quite below normal.

It may prove to have been a very costly oversight if the experience of last winter's curtailment in pig iron production is remembered merely as a shortage of transportation for coke. That has been the common view, but there was a great deal more in the matter than that. The amount of pig iron that was produced, in January and February, from the coke that was available, was far below what would have been produced from that amount of coke under normal working conditions, and as conditions have been partly righted there has been a greater increase in the production of pig iron than in the production of coke.

There were three factors producing an inefficient utilization of the facilities that were available. In the first place, the beehive ovens in many cases did not produce good coke because, awaiting cars, coke was frequently held in the oven too long. In the case of the Connellsville region at least the coke operator was not free to blow out ovens, when car supplies averaged less than necessary to take care of full production by the ovens in blast, because he did not wish to commit business suicide. The absurd system of car distribution in the Connellsville region allots cars, when there is an insufficient supply on the railroad division, in proportion to the number of ovens in blast at each plant. If the operator blows out some ovens this week, his allotment is cut down next week. It is not instantaneous suicide, but the process would be sure. The result of the absurd system of the railroads is poor coke, overburned, and high coke consumption per ton of pig iron produced. In the second place, through irregularities in the receipt of coke, many blast furnaces had to bank at intervals. At such times the coke consumption per ton of pig iron produced is the invariable result when a finite quantity is divided by zero, the symbol being ∞. In the third place, many blast furnaces had to run at gaited rates for long periods. The detached furnace, or pair of furnaces, had no alternative but to make the best of things. A valley furnace manager made what was considered a remarkable record, running at about 50 per cent for several weeks, with an increase of only 10 per cent in coke consumption, but that would be an 11 per cent loss in pig iron over what would have been produced in the industry as a whole if the furnaces operated thus, instead of enough being blown out to give a full coke supply to the remainder.

A compilation showing the coke consumption per ton of pig iron at all blast furnaces last January and February, compared with normal performance at the same furnaces is needed, not to prove that there was much waste of coke last winter, plus much production of poor coke, for the general facts are known, but to emphasize how serious the loss was. If anyone has doubt that there was a very serious loss, let him reflect that conditions as to quality of coke and quantity and regularity of supply were much less objectionable in the year 1917 as a whole than they were last winter. Then let him seek an explanation of the statistical fact that from 1916 to 1917 there was an increase of 2,000,000 tons in the production of coke (Geological Survey) and a decrease of 800,000 tons in the production of pig iron (American Iron and Steel Institute).

No such experience must occur next winter. It is to be hoped that there will be ample transportation facilities, but if there are not, the cars available must be furnished in such manner as to conduce to as regular operation of beehive ovens as possible, and the production of the best coke that can be made. If there is not going to be enough coke at blast furnaces, then the coke must be so employed as to produce the maximum tonnage of pig iron possible with it.

The other problem, referring to the present and not next winter, is to bring about a better balance between pig iron production and steel ingot prodction. In proportion to rated capacities the production of steel ingots has been less than the production of pig iron, and that is a remarkable condition seeing that the iron foundries are not consuming their normal proportion of the total make of pig iron. The condition is due to one or both of two things—too much steel making capacity in proportion to blast furnace capacity, or not enough scrap. As long as pig iron does not accumulate, the individual works manager may be doing his best. He may have a full supply of pig iron, use it all, and get from his open-hearth furnaces only 85 per cent of their rated capacity. With more scrap he might produce ingots at 100 per cent.

The problem of regulating or controlling the scrap movement has been a very difficult one, in comparison with which the setting of prices on plates, or pig iron or even coke, has been extremely simple. It was necessary that scrap prices be limited, but when that was done very little scrap proved available. The dealers insisted that they should be permitted to charge a commission to consumers for handling scrap for them. After much discussion the commission was allowed, April 30, by the War Industries Board. Since then the offerings of scrap have not materially improved. The dealers have not made good on their representations that allowance of the commission would produce scrap, and the showing is particularly in point, because during the pendency of the discussion as to whether or not a commission would be allowed, holders of scrap would naturally keep it, while on the allowance of the commission they would hasten to sell. If there is scrap in the country the scrap should be found, commandeered by the authorities and put at the disposal of open-hearth furnaces.

If on the other hand there is not going to be a normal supply of scrap, the balance fitting the situation should be produced. If there is not enough blast-furnace capacity in proportion to steel-making capacity, the necessary steps should be taken, under authority of the Government, to hasten completion of blast furnaces now in course of erection, or to build new furnaces. There have been some remarkable records of blast-furnace building, when the builders had merely brains and money. Now the work could be hastened by government authority.

Southern Convention of the American Electrochemical Society

Tour of Southern Industrial Centers, Including the New Nitrate Plants at Muscle Shoals and New Power Developments in Tennessee and Alabama—Report of Technical and Business Sessions—F. J. Tone of Niagara Falls Elected President

THAT a war-time convention of scientists and engineers can be held with resultant benefit to the participants, the region visited and the nation at large was amply demonstrated by the American Electrochemical Society in its tour of the Appalachian South during the entire week of April 28. The serious purpose behind the convention and the prospective benefit to the country may be inferred from the action of Director General McAdoo in approving the use of a special train to transport the Society from Washington as far south as Birmingham and return.

AMERICAN ELECTROCHEMICAL SOCIETY

North and South were brought together in a way that could not have been accomplished otherwise, and those who had been strangers to the potentialities of the South realized the possibility of so developing the raw material and power resources of the region as to establish an extensive chemical and electrochemical industry in the course of the next few years. Certainly a good beginning has been made in the production of iron, steel, ferro alloys, fixed nitrogen, cement, wood pulp, coke and its by-products, sulphuric acid, dyes and explosives.

The establishment of two great nitrogen-fixation plants at Sheffield and Muscle Shoals, makes of northern Alabama one of our largest chemical and electrochemical centers. No one could visit these plants without experiencing a sense of pride in what has been accomplished up to date, and a feeling of gratitude toward those who have sacrificed personal interests for the nation's good by devoting their time, talents and professional experience to the vital matter of producing ammonium nitrate.

If the visitors from the North gained inspiration and knowledge from their trip, there is also abundant testimony from the Society's hosts that the meetings brought encouragement and professional gain to them. Notes were freely exchanged and the best of professional fellowship prevailed. That there was tangible gain to both host and guest was therefore inevitable. The nation's war program was uppermost in the minds of all, with the purpose to contribute in every possible way to its advancement.

Assembly and Registration at Washington

As a pleasant prelude to the railway journey, the members and guests of the Society who had gathered at Washington on Sunday, April 28, were shown the courtesy of a private visit to the Executive Offices, Cabinet Room, etc., in the White House, through arrangements made with Secretary Tumulty by the Washington representative of METALLURGICAL & CHEMICAL ENGINEERING. The interest of the visitors centered not

only in the older historical events that had transpired in these rooms, but also in the vital national issues that are there decided from day to day at the present time. The war maps on the walls of the Cabinet Room, corrected daily to show the positions of the contending forces in Europe, were objects of special interest.

Directors Meet En Route

Leaving Washington Sunday evening, the directors of the Society assembled in the observation car for a meeting at which were presented the annual reports of officers and committees. The Society was found to be in excellent condition financially, and a comprehensive campaign for membership was outlined.

On the following day, Monday, April 29, two points in Tennessee were visited, Johnson City and Kingsport.

Johnson City, Tennessee

At this point known as the Gateway to the Appalachian South, the visitors were the breakfast guests of the local Chamber of Commerce. After an address of welcome by Lee F. Miller, president of Chamber, and response for the Society by President Fink, the visitors were taken about the city in automobiles. Time did not permit a visit to the chemical plant of the Clinchfield Products Co., manufacturers of barium products. It was also learned that this concern makes sodium sulphide for the production of dyes at the Federal Dye Stuff & Chemical Corporation at Kingsport, using as one of the raw materials nitre cake from the sulphuric acid works of the Tennessee Copper Co. at Copperhill.

Kingsport, Tennessee

This community is one of the most interesting and promising chemical centers of the South. It has been developed largely through the intelligent efforts of the Industrial Department of the Carolina, Clinchfield & Ohio Ry., and is an excellent example of logical and systematic planning to produce an independent and coordinated industrial center. The variety of chemical and other industries operating here is indicated by a partial list of the products: Cement, wood pulp, tanning extract, clay products, dyes, explosives, leather, wood distillation products and potash from cement. Add to these such local mineral resources as barytes, bauxite, feldspar, manganese, limestone, marble, mica, salt, phosphate and pyrite, and one readily sees a wonderful opportunity for future development.

Arriving at Kingsport the Society assembled at the Inn where addresses were made by V. V. Kelsey, J. F. Johnson and Ex-Governor John I. Cox, who reviewed the early history of the region and explained its resources. At noon the party was taken to Rotherwood Farm where a complimentary luncheon was served. In the afternoon the members were given an opportunity to visit the plants of the following companies: Federal Dye Stuff & Chemical Co., Clinchfield Portland Cement Corp., Kingsport Brick Corp., Kingsport Extract Corp., American Wood Reduction Corp., Kingsport Pulp Corp., and Kingsport Tanning Corp. Particular interest centered in the chlorine, dye and explosives departments of the Federal Co., the continuous causticizing plant[1] of the Pulp Corp., and the Cottrell potash-recovery plant at the Cement Corp., the last being under construction.

HOTEL TUTWILER, BIRMINGHAM, ALA.

Annual Business Meeting

In the evening a complimentary dinner was served at the Inn, followed by the annual business meeting and a dance at the Federal Club.

The annual report of the Directors showed among other items the investment of $2000 of the Society's funds in each of the three Liberty Loans. An amendment to the constitution providing for honorary members was adopted by a large majority. Officers elected

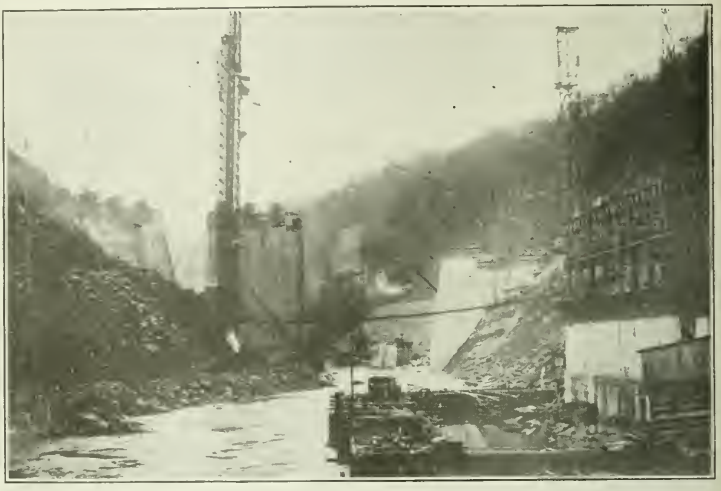
[1] See this Journal April 1, 1918, p. 376.

for the ensuing year were announced as follows: President, F. J. Tone; Vice-presidents, Acheson Smith, H. W. Gillett and R. Turnbull; Managers, C. F. Burgess, E. L. Crosby and C. G. Schluederberg; Treasurer, P. G. Salom; Secretary, J. W. Richards.

Knoxville District, Tennessee

Tuesday morning, April 30, the party had breakfast at Mascot as guests of the American Zinc Co., and later visited the company's zinc-ore concentration plant. An interesting feature of the flotation process at this plant is the preliminary treatment of the pulp with a solution of copper sulphate to aid in the flotation of the blende. The company's metallurgists have been conducting some interesting researches in preferential flotation, the results of which we expect to present in detail in the near future.

Arriving at Knoxville the party was taken immediately by special train as guests of the Board of Commerce and the Aluminum Company of America to see the hydro-electric developments of the latter on the Little Tennessee River. The complete project of this company contemplates the construction of a series of perhaps seven dams and power plants beginning at Alcoa and continuing at intervals up the river, each dam being located at the upper end of the lake created by the one next below. Work is now under way on No. 2 dam at Cheoah, as shown in the accompanying photographs. This dam is 200 ft. high and is reported to be the highest overfall dam in the world. During flood seasons water will flow 10 ft. deep over the crest. The power plant will develop 80,000 hp. The entire project is made possible through an agreement between the Aluminum Company and the Southern Railway providing for the relocation and construction of the latter's railroad.



DAM AND POWER HOUSE FOR ALUMINUM COMPANY OF AMERICA, AT CHEOAH ON THE LITTLE TENNESSEE RIVER

At noon the members of the party were guests of the Aluminum Co. at luncheon at Alcoa, the site of development No. 1.

Technical Session at University of Tennessee

Returning to Knoxville the Society assembled at the University of Tennessee where a technical session was held following a brief address by President Brown Ayres.

Hydro-Electric Power in Quebec and Ontario

A description of possible hydro-electric power development of the waters of the Ottawa River, near the city of Ottawa, and of the waters of the St. Lawrence River, near Montreal, was given by Louis Simpson, industrial engineer of Ottawa. He mentioned especially the Chats Falls, 32 miles west of Ottawa, where it is possible to develop between 110,000 and 120,000 e. hp. The possible head is 50 ft., and ice troubles can be reduced to a minimum. He also mentioned the possibility of constructing a canal from Lake St. Francis to a power house located on the Lake St. Louis, both these lakes being enlargements of the River St. Lawrence. The possible head will be 80 feet, and it will be possible to develop 1,000,000 hp. This development, also, if properly engineered, would be free from ice troubles.

In discussion of this subject Mr. C. A. Winder thought the author was too optimistic regarding freedom from ice troubles as featured in the paper, and also questioned the possibility of developing the amount of power on the Ottawa river as claimed by the author.

Mr. H. S. Randall, Jr., challenged the author's statement that there are but few undeveloped water powers of considerable magnitude, and cited Maine and Labrador as localities where large undeveloped powers still existed. In the latter country there are heads of over 200 ft. where there would be freedom from ice troubles.

Storage Battery Capacities

C. W. Hazeleit, storage battery engineer of the National Carbon Co., presented an interesting discussion of the calculation of storage batteries together with an alignment chart and circular slide rule for calculating these capacities. The use of one million storage batteries for automobile starting purposes imposes new conditions of service which former methods of determining capacities do not cover satisfactorily. It is important that final voltages be standardized as a continuous function of the time rate of discharge, in order that the condition of the cells at end of discharge at any time rate shall be approximately the same, and that all capacity data may be correlative. An equation for this final voltage is suggested and the work of Messrs. Spencer and Naiden was reviewed. They demonstrated that the capacity of the starting battery was a single, definite function of the time.

The conclusions from his work given by the author are as follows:

1. The systematization of storage battery testing demands that all data shall be based on time rates if they are in any way to be universal.

2. The capacity of any Faure or pasted-type starting battery cell between the time limits of 5 minutes and the 100-hour rates of discharge, and of all commercial-type vehicle plates between the 30-minute and 12-hour rates, is a definite single function of the time; *i. e.*, Log I f (T) (Log T) $= K$, where I is the current, T the time, K the capacity in ampere hours times some constant, and (f) (T) a definite function of the time.

3. It is essential to have a universal final voltage equation which is scientific and a definite function of the time. The formula

$$E = 1.85 - \frac{0.448}{\text{Log } T} (T \text{ given minutes})$$

is offered as a scientific and practical equation.

4. The charging and finish-charging rates of any cell should be a definite time rate of discharge. The 7- and 18-hour rates are respectively recommended.

Sign of the Live Electrode

A comprehensive discussion of this subject was given by Prof. W. D. BANCROFT, of Cornell University. Professor Bancroft said the German physical chemists have changed their position several times as to the sign to be applied to the zinc electrode. At present the Germans use the minus sign for the potential of zinc in zinc sulphate solution, as do also the English. In this country the practice is by no means uniform. Professor Bancroft summarized his discussion of the subject as follows:

1. The chemical potential of the zinc in the Daniell cell is greater than the chemical potential of the copper, but the electrical potential is less.

2. With electrodes which form cations the electromotive force is a measure of the difference of the chemical potentials, but has the opposite sign; with electrodes which form anions it has the same sign.

3. Since the electrical potential of the copper in the Daniell cell is higher than that of zinc, and since the zinc electrode is the place of lowest electrical potential, though highest chemical potential, we ought to use the minus sign when speaking of the electrical potential difference Zn | $ZnSO_4$.

4. Calling the zinc potential minus is in line with the practice of all physicists, of the Bunsen Society, and of the Faraday Society.

5. The distinction between chemical potential and electrical potential was stated concisely by Gibbs.

Discussing DR. BANCROFT'S paper, DR. HERING stated that it represented the views of the majority of a committee previously appointed to consider the matter. MESSRS. MOTT, HERING and BANCROFT favored the view just presented, while MR. WATTS thought that the use of the + sign for Na, Zn, etc., and the — sign for Cu, Pt. etc., would follow long established custom and avoid confusion. Dr. Hering stated that the difficulty was that those who originally guessed at the direction of the flow of the current had guessed wrong, with consequent misleading practice in the use of signs. DR. RICHARDS sympathized with the view of Mr. Watts on account of the phrasing of the author's conclusions, objecting to the statement that the electrical potential of Zn is less than that of Cu unless it is specified that it is algebraically and not numerically less.

Resistivity of Porcelain and Magnesia

Tests of the electrical resistivity of calcined magnesite and porcelain were described by P. H. BRACE, research chemist of the Westinghouse Electric & Mfg. Co. The resistivity was measured from 430 to 990 deg. C. of (1) calcined magnesite (impure magnesia) completely fused in an arc furnace and free from cracks and blow holes, (2) molded calcined magnesite baked at 1700 deg. C., (3) porcelain such as is used for spark plug insulators, using direct current. The magnesia had greater resistivity than the porcelain at all temperatures investigated. Uni-lateral effects due to the direct current were noted, and the porcelain gave back electromotive forces up to 0.7 volt.

DR. E. C. SULLIVAN thought the author had neglected to emphasize an important point, viz., that the change in resistance with time was less at high temperatures than at low. President FINK commented on the author's failure to tell how he fired MgO pellets at 1700 deg., and wondered what atmosphere was used. A reducing atmosphere would convert FeO to Fe which would coat the MgO and destroy the resistivity. This would account in part for the better resistivity of molded than fused MgO. DR. NORTHROP thought that results of greater scientific value would be secured if work of this type were done on pure substances of simple composition rather than on complex materials. The results obtained on the latter are empirical and useful only for some practical end, whereas the other procedure would enable us to determine the reasons for the results obtained.

Determination of Gases in Metals

A precision method for the determination of gases in metals was described by H. M. RYDER, research chemist for the Westinghouse Electric & Mfg. Co.

The metal to be investigated is mounted as a thin ribbon or filament in an electric-light bulb, which is then evacuated. The temperature of the filament is then raised by an electric current, and the pump being kept going the gases evolved are continually forced out into a collecting tube. The temperature is raised in steps of 50 deg. C. up to the melting point, and the gases evolved at each temperature measured and analyzed. The bulb is water-cooled, in order to prevent the glass giving off gases on becoming heated. One or two cubic millimeters of gas can be thus measured and analyzed. Silicon steel was found to give off gas abundantly at the Ar_1 point, 730 deg. C. The process of gas analysis is novel and interesting. The CO_2 and H_2O vapor are first frozen out with liquid air, and the remaining "dry" gases are pumped into a small chamber by means of a modified Töpler pump. The CO_2 is then separated from the water vapor by substituting carbon dioxide snow for the liquid air. The quantity of CO_2 released is determined by measuring with a McLeod gauge the pressure due to it in a volume accurately known. It is then pumped out of the system and the water vapor released by removing the carbon dioxide snow. The pressure due

to this is determined by using a mercury U-tube manometer with an optical lever attachment[1].

Oxygen is added to the remaining gases, which have been returned to the main analysis system, and the CO, H_2, and CH_4 burned in a small combustion bulb, a hot platinum filament being used to start the reaction. The CO_2 and H_2O vapor formed are measured as before and the quantity of CO, H_2, and CH_4 determined from this and a knowledge of the decrease in the quantity of the mixture of gases. CO added to the remaining gases and burned provides for the determination of the excess oxygen and any oxygen which might be originally present in the gases. Nitrogen is determined, technically, by difference, but the method permits of a check on its value.

Arc Furnace for Nitrogen-Fixation

A paper on this general subject, not on the program, was presented by E. Kilbourn Scott. He explained briefly the essential differences between nitrogen furnaces and others, to wit: the electrodes are of metal instead of carbon, and the voltage is 5000 or more. One difficulty with all single-phase furnaces is that a great deal of the air entering the furnace does not get into the arc and is unaffected. The author sketched a design of his own furnace, three-phase, in which a maximum of air is reacted upon by the arcs. He described the development of nitrogen furnaces from those of 150 kw. 10 years ago to 4000 kw. now. Yields of nitric acid have now been obtained as high as 85 grams per kw.-hr. at a concentration of 1.3 to 1.5 per cent.

Program at Banquet

On Wednesday evening the Cherokee Country Club was the scene of a banquet tendered the Society by the Knoxville Board of Commerce. Toastmaster Hugh M. Tate gave the proceedings a distinct patriotic tone and commented on the cosmopolitan character of the Society's membership as represented on the Southern tour.

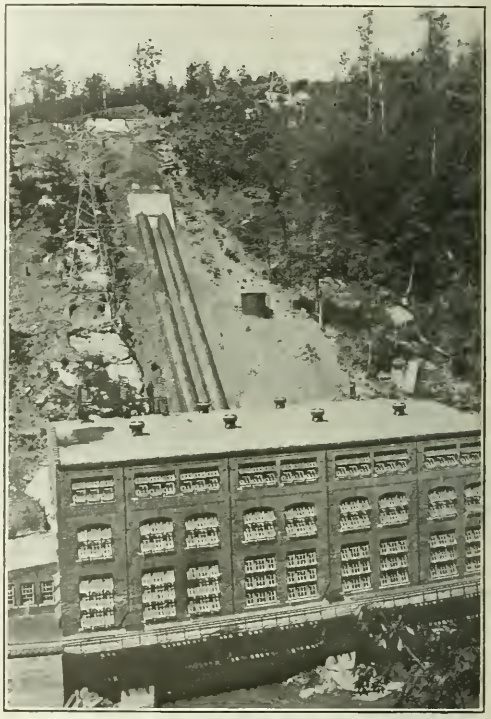
Three notable addresses were delivered following the banquet. The first was the annual address of President C. G. Fink, "Electrochemistry and National Economy." This will be published in full in a later issue.

The second was by John A. Switzer, professor of hydraulic engineering, University of Tennessee, who had during the preceding six weeks made a reconnaissance of undeveloped hydroelectric power sites in eastern Tennessee, capable of developing over 5000 hp. each. His surveys covered the Power, Clinch, Holston, French Broad, Hiwassee, Ocoee and Little Tennessee rivers. Stereopticon views were shown of the localities as well as of proposed dams and reservoirs. In all he described 21 sites at which could be developed a total of 750,000 hp. Prof. Switzer repeatedly explained in connection with several of the projects that the hydroelectric developments would be limited by the present location of railroad lines. Blue-prints were distributed showing the location of the 21 sites.

This third address was given by C. C. Schlueder-berg who spoke on "The Part United States Industries Must Perform to Enable the Allies to Win the War." The speaker showed the importance of our industries and the tremendous demands being made on them in the preparation of war materials. On the subject of abrasives and alloy steels he showed the vital relation existing between electrochemistry and the machine shop.

"It is an established fact that were it not for artificial abrasives, which, by the way, are prepared entirely in the electric furnace, the present output of automobiles, trucks, airplanes, and all other products of the machine shop would not be possible. It is readily conceivable that our success in this war will be at least in a measure due to our ability to produce abrasives artificially by electrothermal means.

"Coupled with the use of high-speed cutting tools made from alloy steel derived largely from the electric furnace, and the use of similar steel for machine parts where great strength is required, we have a good example of how modern scientific achievements have gradually worked their way into our every-day lives without our being aware of the fact."

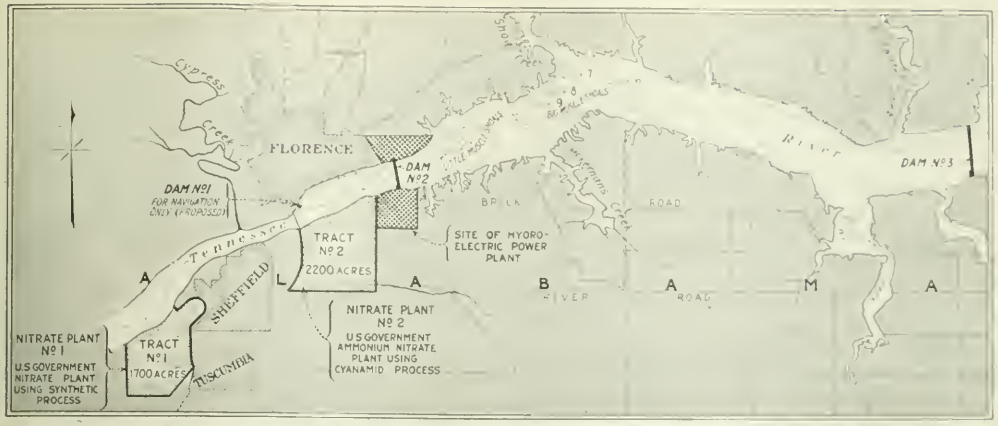


POWER HOUSE AND PENSTOCKS OCOEE NO. 2, TENNESSEE POWER CO.

Chattanooga, Tennessee

Had time permitted at this point the visitors would have found intense interest in the historic ground of Chickamauga Park, Lookout and Signal Mountains, and Missionary Ridge. Fortunately the local committee had so arranged the itinerary of the morning

[1] Reported by J. E. Shrader at the Pittsburgh meeting of the American Physical Society, December, 1917.



VICINITY OF MUSCLE SHOALS, TENNESSEE RIVER, SHOWING LOCATION OF GOVERNMENT NITRATE PLANTS AND PROPOSED HYDROELECTRIC DEVELOPMENTS

as to afford an automobile ride to these points in connection with visits to industrial plants.

The first point of interest was the plant of the Southern Ferro Alloys Co., which was opened by the courtesy of President Paul J. Kruesi and General Manager George L. Davison, both members of the Society. The company is making 50 per cent ferrosilicon at the rate of 20,000 lb. per day. The plant comprises three single-phase furnaces specially designed by the FitzGerald Laboratories. They are of 833 kw. each, or 2500 kw. for the entire plant. The maximum load for the month of April was 3800 hp. This is the first ferrosilicon plant ever opened to the inspection of visitors, and the courtesy was deeply appreciated.

The party was next taken to the Burdette Oxygen Co. for inspection of the electrolytic oxygen and hydrogen plant. The latter gas is used in the adjacent cotton-seed oil refinery of the Wilson Co. for the hydrogenation of oil.

At the plant of the Chattanooga Gas & Coal Products Co., the Society saw the operation of Semet-Solvay by-product ovens and the recovery of ammonia, tar and light oil. The finished products of the plant are coke, gas of 600 B.t.u., tar which is sold to the Lewis Co., light oil which is sold for fractionation, and ammonium sulphate.

After a trip through Chickamauga Park to a cotton mill and bleachery, the party returned to Chattanooga and went by steamer to the Hale's Bar hydroelectric plant of the Tennessee Power Co. Luncheon was served on the boat.

The dam at Hale's Bar is 1200 ft. long and about 40 ft. high. The power house, shown in accompanying view, contains 14 units of 3000 kw. each, generating current at 6600 volts, 60 cycles, 3-phase. This is stepped up to 44,000 volts for transmission to Chattanooga and 120,000 volts for Maryville, Danville and Ashville.

Returning to Chattanooga, the party was taken to Signal Mountain Hotel where a complimentary dinner was served. Interesting addresses were made by E. M. Jones and T. P. Maynard on the resources of the Chattanooga district.

Muscle Shoals District

Florence—Sheffield—Tuscumbia, Alabama

The visit to Muscle Shoals on Thursday, May 2, held unusual interest on account of the immense nitrate plants that are under construction to furnish munitions of war. Here one could gather some idea of the tremendous scale on which the Government has undertaken to provide its requirements of fixed nitrogen. Not only were the visitors impressed with the magnitude of plants, but they came away with a sense of pride in the achievements of American technologists in measuring up to the country's demands. Two huge plants are under construction, and it was learned that the nitrate program will probably call for two more of equal magnitude.

Throughout the day the Society was the guest of the Tri-City community, and members were transported by auto, boat and railroad to see the nitrate plants and the proposed hydroelectric development of Muscle Shoals on the Tennessee river.

A study of the accompanying map will give a clear idea of the full development. In the vicinity of the tri-cities are two Government reservations on which are being built the two nitrate plants, and site for the hydroelectric plant of the future. Three dams are contemplated: No. 1 for purposes of navigation only, No. 2 and No. 3 for development of power. The extent of back water is indicated on the several tributaries to the river.

Nitrate Plant No. 1

This plant is being constructed by the Government and will use a synthetic ammonia process developed by the General Chemical Co. and offered to the Government for the period of the war. A part of the ammonia will be oxidized to nitric acid, and the final product will be ammonium nitrate. Expressed in terms of nitric acid the production of the plant will be 200,000 lb. per day. As soon as the present plant is finished it will be duplicated at this point, and it is reported that a similar plant will be built for the Ordnance Dept. of the Navy. The present plant is be-

ing constructed from an appropriation of $20,000,000 made two years ago. The site was located Sept. 10, 1917; construction was ordered on Oct. 1; contracts were signed Oct. 2, and on Oct. 23 the first material arrived. There have been no labor troubles or undue delays. The number of men employed is 2500. In addition to the plant construction, the Government has also built the necessary white and negro camps, commissary, hospital, etc.

Nitrate Plant No. 2

This plant is being built by the Air Nitrates Corporation acting as agents of the Ordnance Dept., U. S. A., the personnel of the Corporation being practically identical with that of the American Cyanamid Co. whose process has been offered to the Government and is now being installed. It is understood that the proposed plants No 3 and No. 4 will use the same process.

In the auditorium of the village at Plant No. 2 the Society was addressed by Messrs. Young and Pranke of the Air Nitrates Corporation, who outlined briefly the project. Thirteen thousand men are employed and are housed in temporary camps. A permanent village will provide for 12,000 people. There is a recreation hall for each 800 men in camp, and a "movie" house each for the white and negro population. The mess hall is well organized and arranged and feeds 5000 men in 30 minutes. A modern hospital has been built and a workmen's compensation act is in effect. Sanitation is being provided in an up-to-date manner, and fire and police protection are afforded. Aparently nothing has been overlooked. These brief references give an idea of the human problems, as well as those of mere plant construction, with which the Corporation has been confronted. A complete story of the whole undertaking would make interesting reading and should be written some time in the future.

In the cyanamid plant the lime kilns will burn 350,000 tons of lime per year, and the coke dryers will handle 100,000 tons. The lime and coke are fused in carbide furnaces, the product cooled and ground and placed in ovens of one ton capacity each for treatment with nitrogen. The liquid air plant for nitrogen production will have a greater capacity than all similar plants in the United States and Canada.

The cyanamid contains 20 to 21 per cent nitrogen, equivalent to about 25% NH_3. This is cooled, ground and placed in autoclaves where it is treated with steam, producing ammonia. This gas is mixed with air and passed through a heated platinum screen, with resultant oxidation of the nitrogen by catalysis. The oxide gases are then cooled and absorbed. One-half the NH_3 produced in the autoclaves will be thus oxidized and combined with the balance of the ammonia for the production of ammonium nitrate. Power requirements will be 45,000 kw., produced from steam at the plant, and 30,000 kw. to be delivered from hydroelectric plants in the vicinity.

Expressed in terms of nitric acid the production of Plant No. 2 will be 2,000,000 lb. per day.

It is noteworthy that this entire process has been tried and proved in commercial operation for some years, and that no experimental equipment or process is being installed. As a consequence it is expected that operations will proceed smoothly from the beginning.

The construction of Plant No. 2 was determined on Nov. 26, 1917, and the first carload of material was delivered Dec. 20. Considering the short time actual construction has been under way, and the variety of work to be done, there can be nothing but admiration for the results.

J. G. White & Co. are constructing the power house at Plant No. 2 and the buildings at No. 1 with the exception of the acid plant. The Chemical Construction Co. is building the acid plants at both No. 1 and No. 2. Westinghouse Church Kerr & Co. are constructing the buildings at No. 1. Officers in charge at No. 1 are: For the Government, Capt. R. W. Hemphill; for the contractors, J. G. Munson and T. C. Oliver. At No. 2: For the Government, Capt. S. L. Coles; for the contractors, G. W. Burpee, M. T. Thompson and T. C. Oliver; for the Air Nitrates Corporation, J. W. Young.

At Lock 6, Muscle Shoals Canal

As will be seen on the accompanying map, a ship canal extends along the north bank of the Tennessee river. This canal with its nine locks, as well as considerable surrounding land and river islands, will be submerged when the proposed Dam No. 2 is built at the point shown.

It was at Lock 6 on the canal that the Society was tendered a barbecue luncheon following the visit to the nitrate plants. Here with a background of posters showing graphically the various phases of the whole Muscle Shoals project, a number of important addresses were made. C. W. Ashcraft welcomed the Society on behalf of the Tennessee River Improvement Assn., and presented Col. J. W. Worthington, who is generally known as the father of the Muscle Shoals project. He told of the long years of effort to accomplish in the South what had been done at Niagara Falls in establishing an electrochemical industry. He found a warm response to his claim that we need fewer lawyers and more engineers in Congress.

Mr. C. A. Winder addressed the Society on the subject of hydroelectric power. If power-consuming industries are not established contemporaneously with power development the latter is useless. Electrochemical and metallurgical industries offer the best load for hydroelectric plants. The speaker condemned the development of hydroelectric current for domestic and small industrial uses merely on the score that coal would be saved. Such a development might not be able to sell power enough to pay the interest on the investment which normally would be three times that for a steam plant. If the connected load does not consume power every hour of the day there is an economic waste and if it does not consume production for at least 40 per cent of the time the development is a poor venture. Domestic loads for lighting, heating, street railways and light industrial uses should be excluded from hydroelectric loads. Such loads of short duration apply to steam plants where the investment charge is small.

Mr. N. T. Wilcox of the Mississippi Power Co., Keokuk, Ia., spoke of the difficulties originally encountered in developing that project, and encouraged those in charge of the Muscle Shoals project to persevere. He said Alabama was more favored than Iowa in

mineral resources with which to foster industries that would consume power.

Mr. WILLIS G. WALDO spoke briefly on the Muscle Shoals project, stating that there could be a total development of 660,000 hp.; that the nitrate plants and other consumers would take 260,000, leaving 400,000 available for new electrochemical industry.

Mr. FUNASOHU ISOBE, chief engineer of the oil department of Suzuki Co., Japan, spoke for the Japanese who were in the party, expressing their appreciation of the courtesies shown them, and inviting the Society to Japan after the war.

After the exercises the party returned to Florence by way of railroad to Lock 9 and boat to the landing. In the evening a complimentary dinner was served, followed by an informal reception and addresses at the Elks' Home.

Birmingham, Alabama

This point in the South has long been famous for its combination of such raw materials as coal, iron ore and limestone in close proximity, and for low cost of producing pig iron. Recently the iron and steel industry of Birmingham has expanded, and the Tennessee Coal, Iron & Railroad Co. is building a model industrial town at Fairfield in connection with the new steel-plate plant. The operations of this company show that it thinks in terms of human beings as well as vast machines and furnaces.

The first point visited was the blast furnace and steel plants of the Tennessee Coal, Iron & R.R. Co. Most of the operations here were familiar to the guests, but it was a pleasure to inspect so clean and orderly a plant and see the various provisions made for the safety of the employees. The route of the party through the works was clearly marked by a trail of white sand—a convention "kink" that can well be adopted elsewhere.

From this point the party was taken by auto to the Bayview reservoir of the company, where a barbecue luncheon was served and a brief address delivered by Ex-Gov. EMMETT O'NEAL. In the afternoon the by-product coke-ovens were inspected and the new Fairfield steel works were seen in process of construction. A visit was also paid to the works of the American Steel & Wire Co., to see the manufacture of nails, barbed wire and woven wire fence. A short stop was made at the Birmingham Country Club for light refreshments, and later in the evening a complimentary banquet was served at Hotel Tutwiler.

TECHNICAL SESSION

The opening paper dealt with the mineral resources of Alabama prepared by EUGENE A. SMITH, State Geologist. Dr. Smith showed that in 1916 the value of the State's raw mineral production was $37,729,136, while the value of derived products was $55,256,735.

Electrodeposition of Manganese and Manganese Dioxide

Ten papers in all were presented at this session. The first was on the "Electrolytic Behavior of Manganese in Sulphate Solutions," by G. D. VAN ARSDALE and C. G. MAIER, respectively consulting chemist, and research chemist of the Phelps-Dodge Corporation.

This paper presents some preliminary results of work done in an attempt to solve the problem along electrochemical lines. Methods which might be developed from the results presented in this paper will probably not be adapted to the production of manganese for ferro-manganese, or other large-scale metallurgical use, but the data obtained are of interest not only theoretically but may also be of practical use for the production of manganese dioxide, particularly for dry-battery use. The results are summarized by the authors as follows:

(A)

1. Mn may be deposited at the cathode, from neutral solutions with high-current efficiency, from 80-90 per cent, and at voltages from 3 volts up.
2. The effect of increase of acidity is practically to prevent the deposition of Mn at a concentration of 0.36 per cent free H_2SO_4.
3. The deposit is powdery, and ordinary expedients for improving deposition do not give better results to any great extent.

(B)

1. MnO_2 may be deposited at the anode at nearly 100 per cent efficiency.
2. The effect of acid is to decrease the efficiency in cold solutions, but on heating to 65 -75° C. there is very much less effect.
3. MnO_2 may be deposited from warm acid solutions containing more than 5 per cent MnSO, in the form of a dense, black, lustrous film, at current densities up to 25 amp. per sq. ft. (275 per sq. m.) with very high deposition efficiency.
4. Impurities which are reducing agents cause a decrease in current efficiency in proportion to the amount present. Methods of controlling practically the effects of deleterious impurities and the possibilities of a commercial method of treating low-grade ores, and producing a high-grade MnO_2, will be the subject of a later paper.

Electrolytic Copper

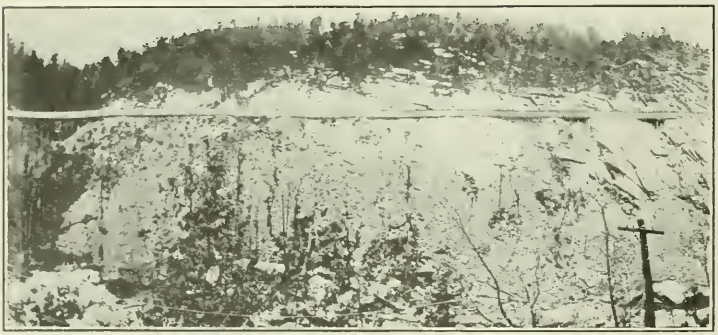
The effect of iron sulphate in the electrolytic precipitation of copper from sulphate solution with insoluble lead anodes was discussed in a paper by Prof. EDWARD F. KERN of Columbia University. He found that the presence of iron reduces the efficiency in the electrolytic precipitation of copper from sulphate solutions, when insoluble lead anodes are used. The higher the percentage of iron in the electrolyte, the lower is the current efficiency, and vice versa. The smaller the amount of copper in the electrolyte, the greater is the reduction of current efficiency as the result of the presence of iron sulphate in the solution. The effect of temperature upon the deposited copper is that smoother and purer copper is formed at 50 deg. C. than at lower temperatures. When no iron is present in the electrolyte, the copper may be almost completely removed, and the current efficiency remain very high, even though the copper in solution may be reduced to as low as 0.2 gram per 100 cc. Iron in the copper sulphate electrolyte causes the copper to deposit less smooth and less dense, irrespective of the ratio of current density at anode to that of cathode. It was seen that less adherent and less dense copper was deposited on the cathode from the electrolytes which contained iron than from electrolytes which contained no iron

and which also contained far less copper. The effect of the presence of iron in the electrolyte is to reduce the voltage required for the electrolysis. When no iron was present the potential between anode and cathode was approximately 2 volts; whereas when iron was present it was lower, in most cases being approximately 1.8 volts.

Copper Electroplating

Experiments with the copper cyanide plating bath were described in a paper by Prof. FRANK C. MATHERS of Indiana University. It was found that the current-yields (ampere efficiencies) at the cathodes were generally lower than those at the anodes, hence the necessity of making the regular additions of sodium cyanide to the baths. Sodium carbonate and perhaps sodium sulphate are valuable additions to the bath. In baths containing near to the minimum of sodium cyanide, sodium hydroxide lowered both the anode and the cathode yields. The anode yields are high in both hot and cold solutions if a proper quantity of sodium cyanide is present, but the cathode yields are much lower in the cold solution than in the hot. A bath containing 6 oz. (4.5 per cent) copper cyanide, 5.7 to 6.3 oz. (4.3 to 4.7 per cent) sodium cyanide and 5.8 oz. (4 per cent) sodium carbonate per gallon operated at 160 deg. to 175 deg. F. (60 to 80 deg. C.) is recommended. This is more concentrated than the baths generally used, but it can be operated at a higher current and the deposits are much better.

Mr. G. B. HOGABOOM criticized the high temperature used, stating that the deposits would be brittle and unsuited to work where bending or soldering were necessary. Furthermore the decomposition of cyanide is too great at 180 deg. F. As to the concentration of solution used by the author, he felt that 3 oz. Ag per gal. would give better results than 6 oz. The latter solution would be certain to yield blisters if used on steel. As for addition agents, NaOH is useless; Na_2CO_3 is useful to "age" the solution, but once added must not be added again. In fact it will increase with time, and hot solutions tend to accentuate this result. At 180 deg. F. a solution will increase from 11 deg. to 30 deg. Be. in three months. He was quite certain that the author's recommendation of a solution containing 5.3 ounces of sodium carbonate per gallon would not give good commercial results as far as the deposit is concerned.



FLUME, OCOEE NO. 2, TENNESSEE POWER CO.

Magnesia-Silica Refractories

The results of tests on the "Crushing Strength of Magnesia-Silica Mixtures at High Temperatures," were described by Prof. O. L. KOWALKE and O. A. HONGREN, of the University of Wisconsin. The mixtures were made from magnesia running 99.92 per cent MgO and silica running 97.66 SiO_2, the balance being lime, iron oxide and water. The mixtures were moistened and pressed into cylinders in a hydraulic press under a pressure of 1500 lb. per sq. in. They were then dried at 2100 deg. C., cut to 1 in. diameter and put under a uniform static load of 66.5 lb. per sq. in. and heated at a uniform rate until they failed. The general summary of results follows:

Pure magnesia failed under a load of 66.5 lb. per sq. in (4.65 kg. per sq. cm.) at 1,680 deg. C.

The addition of silica to magnesia, with seven to eight per cent silica as a maximum, increased the mechanical load-carrying capacity, so that failure occurred only at about 1870 deg. C., which is approximately 190 degrees higher than magnesia supported.

The failure of magnesia cylinders is slow and gradual; that of magnesia-silica cylinders is abrupt.

The superiority of magnesia-silica mixtures with 7½ per cent silica, over pure magnesia, in mechanical load-carrying capacity, appears to be due to the envelope of forsterite, which cements the grains of periclase.

Above 2000 deg. C. carbon attacks magnesia-silica mixtures very rapidly with a marked loss in weight.

Electrolytic Tin

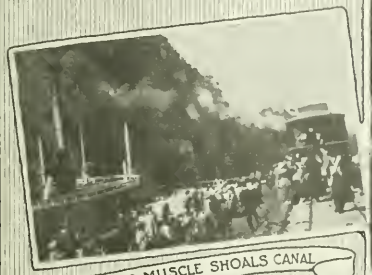
A record of experiments to determine the best electrolyte, the best current density and the best addition agent to use in electro-refining impure tin bullion, with the object of saving the precious metals and getting pure tin was given by Prof. EDWARD F. KERN of Columbia University.

The experiments upon which this paper is based were conducted by Mr. FAN CHEN in the Electrometallurgical Laboratory of the School of Mines of Columbia University. The work was undertaken with the idea of finding a suitable tin electrolyte, and the proper working conditions for electrolytically refining tin bullion, so as to obtain the tin as an adherent, dense, compact cathode deposit.

The anodes were crude tin, cast into thin plates 4 inches (10 cm.) long, 1¾ inches (4.4 cm.) wide, and ⅜ inch (0.94 cm.) thick. Analysis gave (in per cent) 96.0 tin, 0.5 iron, 0.1 arsenic, 0.2 antimony, 2.0 lead, 0.6 copper, 0.1 bismuth, and 0.5 silver. The cathodes were made of sheet tin 1/64 inch (0.4 mm.) thick, and larger than the anodes by a quarter of an inch (0.6 cm.) on each of the two edges and bottom.

The electrolytes which were selected for trial were solutions of stannous chloride ($SnCl_2$), sodium-stan-

GLIMPSES *of* SOUTHERN TRIP
American Electrochemical Society



AT LOCK 9, MUSCLE SHOALS CANAL

BARBECUE AT BIRMINGHAM

AT LOCK 6, MUSCLE SHOALS

BARBECUE AT LOCK 6

TUSCUMBIA, ALA.

DAM AT CHEOAH

APPROACHING ROTHERWOOD FARM

HT

nous chloride ($SnCl_2.2NaCl$), ammonium-stannous chloride ($SnCl_2.2NH_4Cl$). Magnesium-stannous chloride ($SnCl_2.MgCl_2$), sodium-stannous fluoride ($SnF_2.2NaF$), stannous fluosilicate ($SnSF_6$), and a mixture of acid solutions of stannous fluoride and fluosilicate. Each of these solutions was prepared to contain 5 grams of tin per 100 cc. The experiments led to the following conclusions:

Addition agents are necessary for the electro-deposition of dense adherent deposits of tin.

Stannous fluosilicate electrolyte is the best of the electrolytes tried for the electrolytic refining of crude tin. Free hydrofluoric acid and free hydrofluosilicic acid are beneficial; HF 60 per cent of the total acid content is not detrimental.

The deposits of tin which are formed in sodium-stannous chloride, ammonium-stannous chloride, and stannous chloride electrolytes are similar, when addition agents are present.

Aloin was found to cause the formation of the best deposits when added to stannous fluosilicate electrolytes, in amount corresponding to 1 gram per 500 cc. of electrolyte.

Peptone, when added in amount of 1 gram per 500 cc. of electrolyte, gave good deposits from all of the electrolytes reported in Tables II, III, IV, and V.

Gelatine, quinoline and oil of cloves, when present in amounts of 1 gram per 500 cc. of electrolyte, did not improve the deposition of tin, except in the case of the stannous fluosilicate electrolyte.

Boric acid, when added in amounts of 1 gram per 1500 cc. of electrolyte and up to the saturation point, did not improve the electro-deposition of tin, except when added to stannous fluosilicate electrolyte in amount corresponding to 1 gram per 1000 cc. of solution.

Mr. WITHERELL sounded a note of caution against the use of addition agents, saying that they frequently worked well for a while, but that after a few weeks trouble would come, due to the decomposition of the agents, particularly those of organic nature. These troubles cannot be discovered in the laboratory, and hence it is advisable to use addition agents in only part of the plant at any one time.

Rusting of Rails

Under the title "Why Busy Rails Do Not Rust," Prof. OLIVER P. WATTS, of the University of Wisconsin, reviewed at length observations made since 1843 on the fact that idle rails appear to rust faster than busy ones. He gave the following explanations offered by previous writers for the lessened corrosion of rails in use:

1. That vibration causes shedding of rust and so, in the presence of less of this stimulator of corrosion, rusting will be diminished.

2. That vibration breaks up areas of different potential that are naturally present on the surface of iron or steel.

3. That there is a voltaic action between bright or polished and dull or rough iron which, in some manner not explained, lessens the total corrosion of the rail.

4. That the rise in temperature produced by the passing of trains causes a more rapid evaporation of moisture from the used rails, and for this reason lessens corrosion.

Prof Watts' results showed that an e.m.f. exists between the top and other portions of used rails acting in such a direction as to protect the rest of the rail; but it is manifestly impossible that a current generated by corrosion of one part of a bar of metal in a single solution shall, by its protective action on the other part, lessen the total corrosion.

The author presents the view that the lessened corrosion of rails in use is due to a combination of two of the causes mentioned by previous writers, viz., voltaic action between strained and unstrained metal in the rail, which results in a slower formation of rust on the cathodic portions, and that thereby the normal accelerative action of rust is greatly diminished; and the complete removal of rust from the top of the rail, where it would otherwise form most rapidly and exert the greatest accelerative effect on rusting.

Electric Furnaces

The **Vom Baur arc furnace**, a new design, was described by C. H. VOM BAUR, consulting engineer of New York City. The furnace is particularly designed for melting ferromanganese or ferrosilicon, or melting down cold charges for steel castings. The furnace design was created after observing many different electric furnaces in operation, and also operating many of them. It is covered by U. S. Patent No. 1,252,633, and was designed to remedy several defects of previous arc furnaces of the simpler, polyphase, solid bottom type.

It has a 2-phase, 3-wire connection, with the three electrodes in a straight line, the center electrode carrying the heavier current, all contained in an oval-shaped hearth, which has an equal heat gradient at the slag line. As the design follows easy, natural lines, furnaces as small as ½-ton and as large as 15 tons are now being made. In the larger furnaces, the rolling features of the Wellman type have been adopted, whereas with some of the smallest the tilting is accomplished, keeping the spout almost stationary, by having the fulcrum directly beneath it, which facilitates pouring into small hand-ladles.

The advantages of this shape of hearth, together with the 2-phase, 3-wire connection, and the electrodes in a straight line, are claimed to be many and far reaching. For instance: when burning in a basic bottom, as the electrodes are in a straight line, the heat of the arcs can be transmitted to a scrap carbon electrode lying horizontally on the bottom directly beneath all three vertical electrodes, and thence to the basic layer being sintered. Whereas, with arc furnaces having their three electrodes placed in triangular form, or those using four electrodes in a rectangular form, two carbon blocks at least are necessary in order to bring the electric arcs into play for sintering in the bottom. Other advantages in melting down and in minimizing heat losses were explained.

The **Booth-Hall electric furnace**, also a new design, was described by W. K. BOOTH, general manager of the Midland Electric Steel Co., Terre Haute, Ind. It is a vertical arc furnace with conducting hearth and

is built either single-, two-, or 3-phase to suit the conditions at the place of installation, the general principle being a furnace having a solid hearth which becomes conductive of electricity when hot, and the use of an auxiliary electrode which acts as a return for the electric current until the hearth becomes heated and conductive. The furnace is particularly

INTERIOR OF FLUME FOR OCOEE NO. 2, TENNESSEE POWER CO.

intended for melting down cold charges for steel-casting foundries. An illustrated description was published in METALLURGICAL AND CHEMICAL ENGINEERING, February 15, 1918, page 211.

Electric Steel Castings

A continuation of a report of foundry experience making electric steel castings was given by R. F. FLINTERMAN, of the Michigan Steel Castings Co. The former report was read at the Detroit meeting in May, 1917, and was published practically in full in our issue of May 15, 1917. In this paper a process referred to as "reversed duplexing" was mentioned as having great possibilities and it was intimated that this process would be tried out. In the present paper Mr. Flinterman says the process has not been tried out, as they have been able to increase their tonnage to such an extent with their present furnace that the addition of another furnace would not be economical. An inspiration for a change in furnace construction was derived from the paper by A. A. Meyer on "Electrical Characteristics of Electric Furnaces," which was also presented at the Detroit meeting in May, 1917 (see this journal, May 15, 1917). In this paper several causes of high-voltage drop in the bus bars were discussed and these were made the basis of changes in Mr. Flinterman's Heroult furnaces.

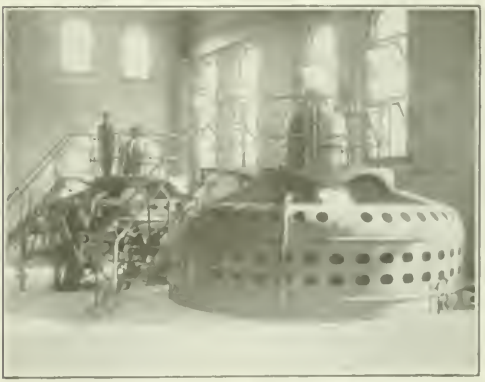
We quote from his paper as follows:

"In case of both the bus bars between the transformers and the flexible cables, and also the bus bars on the furnace itself, the $\frac{1}{4}$ x 6 in. (0.6 x 15 cm.) copper bars were spaced by means of $\frac{1}{4}$ x 3 x 6 in. (0.6 x 7.5 x 15 cm.) copper spacers. These spacers have all been replaced by vulc-asbestos spacers. In addition, mica insulation was placed between the various bus-bar leads in such a way that the different parts were isolated and made to act as nearly as possible independently from one another. We find that these small changes have made a great change in operation of furnace. From all indications it would appear that the drop in voltage found by Mr. Meyer has been much reduced. This point will be more clearly established by a series of tests which will be undertaken in the very near future.

"At any rate, it is safe to asume that part of the drop was due after all to skin effect, and that it was not entirely due to induction set up in the steel construction at rear and top of furnace, as Mr. Meyer stated in his paper.

"Under the circumstances, it would be much better to do away with the solid bus construction entirely. The later Heroult furnaces are now constructed as is our 3-ton furnace, where the flexible cables are carried direct to the upper part of the steel structure at back of the furnace. It would seem even better to us to carry the flexible cable directly through to the electrode clamps. There would of course be some induction set up in the steel structure, but we do not believe there would be as much voltage drop as there is now. At any rate, as now constructed, our furnaces are running much faster than formerly, and our current consumption is regularly lower than it was before. On one run of 24 hours, 11 heats were taken from the 3-ton furnace. Our average current consumption for the week, including all delays and stops, is running under 625 kw. hours per ton. Since our work is light, and our metal must be brought to a very high temperature, we consider this a very low consumption.

"With our tonnage brought to this high figure, our floor capacity is taxed to the utmost. An additional furnace would therefore be superfluous and uneconomical. The only opportunity for 'reversed duplexing' in our own shop would be to change the 3-ton furnace to basic lining. Under present pressure of



GENERATORS, OCOEE NO. 2, TENNESSEE POWER CO.

work this is of course impossible, and the actual trial of duplexing must therefore wait.

"There is one other point referred to in the writer's former paper which I desire to touch upon here, namely, the great possibility of the electric furnace in production of the various steel alloys. This one feature is perhaps of greater value and interest to the makers of tool steel, but I am firmly convinced that there are wonderful possibilities in the manufacture of heat-treated alloy-steel castings. This is

a field which is almost untouched and is well worth investigating.

Owing to lack of time the following papers were read by title only:

Brittleness Produced in Steel Springs by Electroplating, by O. P. WATTS and C. T. FLECKENSTEIN.

Experimental Carbon Cell, by S. A. REED.

Methods for Commercial Analysis of Ferrosilicon, by E. M. ANGER.

Thermoelectric Force of Some Alloys, by M. A. HUNTER and J. W. BACON.

Anniston, Alabama

This city was interesting from a technical point of view on account of the manufacture of electric ferroalloys and electric pig iron from scrap.

The Society was entertained at breakfast at the Anniston Inn, after which Mr. THEODORE SWANN, President of the Southern Manganese Corp., outlined the technical features of the local plants. The Southern Manganese Corp. is operating eight 3-phase furnaces on ferromanganese, and in April produced 5 per cent of the United States output. The Anniston Steel Co. is producing pig iron from steel scrap melted in 6-ton Heroult furnaces. Three additonal furnaces of the Southern Manganese Corp. have been leased to another company, which is making ferrosilicon.

Mr Swann stated that they expect to mine all their manganese within eight miles of Anniston and produce 8 per cent of the United States output. They are not looking for bonanzas and expect to get their supply in small lots from mines equipped with one or two log washers and producing up to 10 tons per day each. Such

DAM AND POWER HOUSE, OCOEE NO. 1, TENNESSEE POWER CO.

properties can be equipped for $2000 and will be ahead of the game when they have shipped their third carload of ore. Taking the cue from former practice of washing five tons of brown iron ore to get one ton of product, Mr. Swann believed they can afford to wash 50 tons of manganese dirt for one ton of 40 per cent manganese concentrate.

At present the slag from the electric furnaces is being sold to blast furnaces for recovery of the manganese content. Experiments on the retreatment of slag in the electric furnace showed that from slags containing 12 to 14 per cent Mn it was possible to produce a 60 per cent ferromanganese at the third or fourth tap, but the procedure was not commercially profitable. Silicomanganese has been made from the slag pile, running 69 per cent Mn and 19 per cent Si. The product requires more than three times the power necessary for ferromanganese. The furnaces used in the old plant are the type of carbide furnaces of the early nineties. Con-

HALE'S BAR POWER HOUSE, TENNESSEE POWER CO.

struction of the new plant was begun on June 25 and was turning out ferromanganese in 23 days. Mr. Swann stated that the company is willing to impart information to anyone who can use it for the benefit of the Government at this time. The plant had thus been opened to the engineers of the Anaconda Copper Co., which recently prepared to make ferromanganese at Great Falls, Mont.

RETURN TO WASHINGTON

The special train left Anniston Saturday noon and arrived at Washington Sunday afternoon, where the party disbanded and returned to their homes. The meeting and trip was one of the most successful affairs ever undertaken by a society and was pronounced the best of the meetings of the American Electrochemical Society. It was no junket undertaken for pleasure or personal profit alone, and if the report of the proceedings is replete with items of entertainment, that is to be charged to the inevitable Southern hospitality which had to find expression even in war time. The presence of a dozen ladies in the party added to the pleasure of the tour. They were specially received and entertained at every stop.

The trip was a hurried reconnaissance of a remarkable territory and the sentiment was frequently expressed that a future meeting should be held in the South at a central point. For the excellent arrangements of the trip the Society is indebted to Mr. Charles F. Roth and his committees at the points visited.

Iron and Steel of Canada.—We are glad to welcome a new member to the ranks of metallurgical journalism in America in *Iron and Steel of Canada*, a monthly publication appearing in Montreal in February. The high quality of the publication can be inferred when it is known that Alfred Stansfield, professor of metallurgy of McGill University, is editor in chief. Its field is "the science and practice of the iron, steel, foundry, machine and metal-working industries."

The Future of the American Electrochemical Industry

By S. W. Maher*

IT IS well known that the present center of the electrochemical industry in this country is in the Niagara Falls district, and that the situation there as regards an adequate power supply for the future development of this industry is becoming a very serious problem. In view of this fact it is doubtful if Niagara Falls will remain the center of this industry. Even if it should remain the leading electrochemical district of this country, it is evident that new sources of power must be found to take care of the expansion and development that is already beginning to tax the capacity of the power plants at Niagara Falls. The recent phenomenal growth in the demand for products manufactured by the electric furnace makes the question of great interest to the American engineer and manufacturer.

It is true that the war has brought about an unprecedented demand for electrochemical products, but it is not believed that the industry will decline to any great extent with the cessation of the war. On the contrary, the products of the electric furnace and of electrolysis depend for their demand largely on the ordinary and general growth of industry in this country. The truth of this assertion is easily seen when the chief products made with the help of electric current are considered.

The production of machinery is depending more and more on artificial abrasives, which are important products of the electric furnace. In fact, the value of artificial abrasives is already greater than that of natural ones. Of great importance also are the special alloys used for cutting metals at high speed, and the special steels of various kinds used in so many of the machines that are manufactured today. Aluminium, whose consumption is growing rapidly, and whose uses are just beginning to be understood, is entirely an electric furnace product. Mention may also be made of the electric production of steel, the production of calcium carbide for cutting and welding purposes, and the production of such metals as calcium, magnesium and sodium.

The products of electrolysis in solution are chlorine (which is of the utmost importance to the dye industry), oxygen, caustic soda, and the electro reduction of aromatic nitro compounds. This latter offers a field of great promise as it has yet been little worked on a commercial scale. With the present scope and importance of electrochemical industry, and its future requirements before us, it is proper to refer again to the situation at Niagara Falls. As already stated, this is the center of this field of work in the United States, and as such it is a vital factor to other industries scattered over the country. For instance, the cutting off of abrasives from this point would seriously cripple if not utterly destroy our airplane industry. If continued much longer the apparent lack of appreciation of the importance of the stable and growing electrochemical industry will make itself felt in no uncertain manner. It is believed, with no fear of contradiction, that there is not enough power available at Niagara Falls to adequately support the increasing demand of some of our most important electrochemical industries.

Canada is in a position to control the greater portion of the power supply at Niagara Falls, and in fact has been selling the American manufacturers a considerable quantity. Already, however, Canada's needs are increasing rapidly, and she is, therefore, forced to cut off our supply. As her demands continue to grow, the power situation must become more and more acute for us. In view of these facts, the American electrochemical industry must find other fields where it can expand and grow to meet the requirements of our industrial development.

The ideal site for an electrochemical industry should have not only cheap electric power, but certain raw materials such as salt, lime, coal, bauxite, iron manganese, chrome and nickel. There should also be adequate facilities for assembling the raw materials and distributing the finished products to the market. Of special importance, although not absolutely necessary at the point of production, are such materials as are necessary in the construction and maintenance of electrochemical plants. Among these may be mentioned fireclay, asbestos and mica, as well as refractory materials of all kinds.

Having shown the necessity for seriously considering at this time the future of the American electrochemical industry, attention is now called to a section of our country that we believe offers exceptional advantages for electrochemical plants. We refer to that portion of the southern Appalachian region that lies between the Cumberland Mountains on the north and the Blue Ridge System on the south, and comprising parts of Southwest Virginia, East Tennessee and Western North Carolina. This region offers great advantages in water and steam power, raw materials for manufacturing and building, and has good transportation facilities.

The territory is drained by the waters of six rivers, namely: the Powell, Clinch, Holston, Nolichucky-Toe, Wautauga and French Broad. The primary sources of these rivers are found in the springs, which are supported by abundant rain fall. The rainfall in this part of the country is so heavy and so uniformly constant from year to year that a constant and never failing supply of water power is assured at all times.

The approximate indicated minimum horsepower of these rivers is: Powell 13,000 hp.; French Broad 132,000 hp.; Nolichucky-Toe 61,000 hp.; Wautauga 30,000 hp.; Clinch 34,000 hp.; Holston 47,000 hp. This gives a total minimum indicated horsepower of 328,000. It should be understood that the above figures do not include storage, or any of the tributaries of these rivers.[1]

In addition to the water powers mentioned above, this territory is well situated with respect to the coal fields of Kentucky, Virginia and Tennessee. The amount of coal available from these fields is shown to some extent by the tonnages produced in the respective states in the year 1915. In this year Virginia produced 8,000,000 tons, Kentucky 21,000,000 tons, and Tennessee 5,000,000 tons.[2] These fields possess ample reserves,

*Chemist-Geologist, Carolina, Cinchfield and Ohio Railway.

[1] These figures are taken from "The Water Powers of Tennessee" by J. A. Switzer.

[2] From "Resources of the United States," by the United States Geological Survey.

and are tapped by railroads with strictly modern equipment. This assures a cheap and large supply of first class bituminous coal, which can be transported to prospective plant locations on a very low freight rate.

The mineral resources of this region are very extensive and will furnish many of the raw materials necessary to the electrochemical industry. These minerals are situated on or near the railroad, and, therefore, are easily assembled at points of manufacture. Southwest Virginia offers coal, salt, silica sand and high-calcium limestone, as well as iron and manganese. East Tennessee has commercial deposits of iron, manganese, phosphate and bauxite. Western North Carolina has low phosphorus magnetite, brown hematite, titanic magnetite, nickel and chrome. The proximity of these deposits to the railroad and water powers make the problem of assembling this material a very simple one, and, furthermore, excellent and quick freight service is available for distributing the finished products to the markets of the East, North, South and West.

Building material occurring and produced in this region are Portland cement, brick, tile, sand, lime, granite, sandstone and a variety of timbers, both hardwoods and softwoods.

Other materials that are found in this territory are asbestos, mica, fireclay and other refractories. The hardwoods found so abundantly in this territory are a source of charcoal and acetone, which are of great value. A large wood alcohol plant is now being constructed.

Hence, it is evident that the Southern Appalachian territory offers an interesting field for closer investigation by the electrochemical engineers. It has the necessary factors for cheap power; is has the raw materials, the assembling and distributing facilities, the building material and other advantages of importance to the electrochemical industry.

Johnson City, Tenn.

Approximate Determination of the Minerals in Concentrates by Means of the Microscope

By Kirby Thomas and Frederick W. Apgar

MICROSCOPIC examination of the concentrates and tailings from preliminary laboratory and mill tests furnishes a ready means of checking operations and observing the results of various adjustments and modifications of process during experimental work. Large-scale mill operation may thus be instituted along most promising lines, avoiding the chance of any radical later rearrangement of plant at considerable cost or the abandonment of a plant which in practical operation was found totally unfitted to the ore at hand. Such examples of wasted expenditure may be found in almost any mining district.

A simple and rapid method for obtaining an approximately accurate quantitative mineral analysis of a concentrate by means of the microscope gives immediate results when they are most wanted, whereas a complete chemical analysis with the calculation involved for recasting in terms of minerals requires considerable time and expense and the results are often delayed until after the immediate necessity for them is past.

A portion of the concentrate which has been reduced in bulk carefully by the application of approved methods of sampling is taken, spread out evenly on a glass microscope slide and placed on the stage. A magnification of 30 to 60 diameters is generally found sufficient for this purpose. The number of grains of each of the various minerals within the field of the microscope may then be counted, at the same time noting the general average size of grain for each.

This operation is repeated from five to ten times over the slide at random points and the results tabulated. Three or four slides may be prepared if desired and two to three counts made on each. If all the grains are approximately equal in size, the *total* number of grains counted of each of the various minerals, reduced to parts per hundred, will represent a percentage *volume* analysis directly; otherwise a simple correction must be applied to allow for the difference in grain-size of the various mineral components.

The relative volume so obtained multiplied by specific gravity and again reduced to parts per hundred will give the desired weight percentage of the different minerals and will be found sufficiently accurate for most practical purposes. The method will take considerably less time than would be required for chemical analysis recast in terms of mineral percentages.

In most cases it will be found that the critical minerals in fragment are easily distinguished by color and surface appearance so that the count may be made very easily and quickly. Certain gangue minerals such as quartz and feldspar are classed together and where two similar appearing dark sulphides occur together in an ore it is not generally necessary to distinguish between them. As a rule milling problems are concerned with the relative proportion of sulphides, oxides, silicates or carbonates and gangue, or with sulphides which differ materially in appearance and gangue.

If a large proportion of the grains are complex in character, minerals included in gangue, the approximation will be less accurate but at the same time perhaps this very fact is of the utmost importance as suggesting the desirability of finer grinding.

TABLE I—MICROSCOPIC ANALYSIS OF FLOTATION CONCENTRATES

Counting all grains in field over 0.03 mm. in size
Considerable dust-like particles from 0.001 to 0.003 mm.
Grains of the different constituents average fairly uniform in size.
Green mineral slightly smaller and quartz slightly larger than the black metallic.

	No. Grains	% Area	No. Grains	% Area	No. Grains	% Area	No. Grains	% Area
Green transparent (Chrysocolla) Size 0.03 to 0.12 mm.	72	38.0	48	34.0	57	34.0	84	43.0
Quartz Size 0.04 to 0.20 mm.	46	24.0	36	26.0	32	19.0	40	21.0
Brown transparent Size 0.1 mm.	1	0.5	1	0.7	1	0.6	1	0.5
Red transparent (Cuprite) Size 0.03 to 0.08 mm.	2	1.0	0	0.0	2	1.0	2	1.0
Black Metallic Size 0.03 to 0.17 mm.	70	37.0	48	34.0	73	43.0	64	33.0
Bronze to yellowish Size 0.08 to 0.15 mm.	0	0.0	7	5.0	3	2.0	4	2.0
		100.5		99.7		99.6		100.5

A typical example of the results obtained by this method on concentrates from a flotation experiment is given in Table I. The approximate results would indicate that by bulk the copper minerals in the concentrate were about 79 per cent, distributed as indicated, which by calculation would show a weight content for the concentrate of copper minerals of from 85 to 90 per cent. Further calculation if necessary will indicate the metallic content.

Milling in Cyanide Solution

A Comparative Analysis of the Results of Milling Gold and Silver Ores in Cyanide Solution in Place of Alkaline Water; and the Relation of Amalgamation in the Selection of Method

By A. W. ALLEN

THF object of the present article is to bring forward the pros and cons of milling in cyanide in place of alkaline water as a diluent of the ore and pulp in wet-crushing and grinding operations.

One of the chief advantages accruing from the practice of milling in cyanide solution is the intimate contact resulting between coarse metal and solvent, caused by the action and operation of the grinding machinery. This advantage shrinks in importance in the case of amalgamable ore when consideration is paid to the fact that milling in cyanide precludes the possibility of amalgamation being practiced, or renders its function only partly effective if any quantity of the metal in an ore can be obtained by a simple and direct method an explanation is needed for the substitution of a complicated solution alternative which actually recovers only a proportion.

In the case of gold ores and in spite of clear enunciations of the actual facts disclosed by milling results a good deal of misapprehension exists; and the question has been complicated and the issue beclouded by reference to the efficiency of amalgamation with unamalgamable gold ores. Such considerations do not affect the question. If a proportion of the gold in an ore is amalgamable then practically 100 per cent of this proportion is recoverable. If cyanidation replaces amalgamation as a treatment process for this proportion, then only from 90 to 95 per cent is usually recovered.

The arguments advanced in favor of part amalgamation have, as far as I am aware, only been used as referring to amalgamable gold; and it is therefore an untenable claim to advance that this gold may not amalgamate. In special but exceptional cases the recovery of gold by cyanidation may reach 97 per cent, but in no single instance has a recovery of 100 per cent been recorded with any professional claim to verisimilitude. These facts may be substantiated by milling barren material similar in physical characteristics to the ore usually found in gold treatment plants, and mixing with this a proportion of coarse gold recovered by the amalgamation process. No matter how fine the ultimate division of the mixture there will remain a small percentage of the original amount of gold associated with the gangue after complete milling in cyanide and filtration treatment.

Extraction Versus Recovery

A second method of beclouding the issue is to draw attention to the total amount of gold dissolved or extracted by cyanide and to ignore the question of recovery. Finely divided gold may be completely dissolved in a cyanide solution and thus completely extracted from the ore; but when associated with gangue as an average grade material such extracted gold cannot be completely recovered by any combination of known metallurgical processes operating on a working scale. All or nearly all the gold may be dissolved and a high percentage may be recovered as bullion. The loss of the balance is all that is needed to influence the contention in favor of efficient amalgamation of gold ores.

A case in point is afforded by the recent publication of the results of treatment in a milling-in-cyanide plant where amalgamation has been abolished. Previous milling operations showed that 86 per cent of the gold could be concentrated in about 7 per cent of the tonnage. Tests on the 93 per cent remaining, constituting the tailing after amalgamation and concentration, showed that this could be reduced to 45 cents per ton by crude cyanide methods, and apparently without further grinding expense. These results would seem to indicate the lines along which a very successful scheme of treatment might be formulated.

The 45-cent residue was, however, considered discouraging and further experiments on a sand of normal fineness for leaching purposes were apparently not considered. Tests were then made to see how much gold could be dissolved by an agitation treatment, and the results indicated that all the gold was soluble provided grinding was carried far enough. "Extractions" of 99.7 per cent were obtained in the laboratory; and as a result of these tests it was decided to grind and regrind the 7 per cent of the concentratable material without separation from the 93 per cent of low-grade ore, a scheme which provided that every particle of worthless rock and absorbent colloid should be thoroughly accepted in as rich a solution of gold as possible.

The fact that all the gold is soluble in cyanide is now reaffirmed, but actual results would seem to indicate that from 40 to 50 cents per ton has been lost in the residue from about 400,000 tons treated by an all-sliming, milling-in-cyanide process.

If the question of the further recovery of gold from the residue is considered it must be realised that the 7 per cent of material which might have been concentrated for special treatment is now intimately mixed with a large tonnage of gangue, and that any additional treatment of this residue may be deemed infeasible by known methods of handling. Even if the ratio of concentration was reduced to 10:1 there would still remain argument in favor of the isolation of the special product. A dump of 400,000 tons of residue carrying about 40 cents per ton in gold is valueless. A dump of 10,000 tons of clean pyritic concentrate carrying about $2 per ton in gold is a valuable asset in sulphur content as well as gold.

Tests on the concentrate in question showed that 96 per cent of the gold could be extracted by straight cyanidation, and apparently without previous roasting, or amalgamation during regrinding. Practical results on pyritic concentrate invariably show that roasting reduces the cost of subsequent grinding and leaves

cyanide consumption. Sulphur is urgently needed at the present time but "up-to-date" methods for the treatment of a simple gold ore involve not only the loss of the pyrite but a recoverable percentage of gold associated with it. By concentrating the pyrite and recovering the sulphur the gold is actually liberated, and the highest possible percentage may then be recovered.

The foregoing example adds weight to the contention that after milling in cyanide and all-sliming the actual residue value is not by any means in inverse ratio to the solubility of the gold in cyanide solution; but rather in direct ratio to the amount of gold which is permitted to pass into solution and become intimately associated with the worthless constituents of the ore. Practical results go to prove that a comparatively high percentage of such soluble gold is lost in the residue after what are generally termed "improved" methods of ore treatment.

Influence of Colloids in Absorption of Metal

Absorption of dissolved metal by colloid particles plays an important part in the all-sliming process and may be cited as one reason at least for the non-recovery of all the extracted metal. It is no longer possible, in the light of contemporary investigations, to speak definitely of dissolved or undissolved metal after cyanide treatment, when it is impossible to determine how much of the metal has been dissolved and absorbed, and how much has been untouched by the solvent. Reduction in actual recovery as a result of the absorption of metal-bearing solution is a phase of treatment not encountered in amalgamation practice. Absorption and adsorption are phenomena which are largely influenced by the question of fineness of division; and this fact may serve to explain the reason for the comparatively high residual content after milling and fine grinding in a cyanide solution carrying valuable metal, or in which a proportion of the metal is immediately dissolved.

Amalgamation Inefficient for Silver Ores

In the case of silver ores the advantages are in favor of milling in cyanide and the abolition of amalgamation, other than in exceptional cases such as at Nipissing. The reason is that on normal grade ores amalgamation is an inefficient process at best, a circumstance largely due to the fact that the specific gravity of the metal is comparatively low, and also that it invariably occurs in combinations unfavorable to high extractions by this process.

An additional factor influencing the decision to abolish amalgamation in favor of milling in cyanide with silver ores is found in the circumstance that the finest grinding is necessary in any case, whereas with gold ores it is almost invariably unnecessary, although often adopted to eliminate the need for separate treatments of sand and slime and to simplify the subsequent methods by handling the pulp in one solution and solution-displacement operation.

If regrinding of mill pulp could be done after thickening there would be a field for usefulness in the tube-mill in helping to dissolve gold remaining associated with the ore after efficient amalgamation had recovered its maximum amount. But efficient milling and regrinding usually involves classification and ample dilution, hence milling in water and regrinding in solution is impracticable under ordinary circumstances.

Dry Crushing Precedes Roasting and Cyaniding

Dry crushing is usually practiced from necessity and not from choice, but this method of reduction is indicated in the case where roasting follows crushing and precedes cyanide treatment. In this instance it has been found an advantage to regrind in weak cyanide solution in an apparatus available for amalgamation. The cyanide present tends to cleanse the gold and assist amalgamation; and as much as 40 per cent of the gold content in refractory ore may be recovered by this method at a minimum cost for labor and material, the balance being in a favorable condition for subsequent cyanide treatment.

Water Consumption Influences Method of Treatment

On the question of water consumption there are advantages in favor of milling in cyanide in those cases where efficient thickening is out of the question, or where the residue is discharged at under 20 per cent moisture. Under normal conditions, and by inexpensive means, sand tailing may be dewatered to carry the same percentage of moisture as when being dumped. Slime pulp can usually be dewatered by gravitational settlement and thickening to from 25 to 35 per cent moisture, or from 15 to 25 per cent by means of continuous-operation vacuum filters. The residue from decantation or vacuum-filter plants usually carries a fairly high percentage of moisture so that there need be no accumulation of solution, and in most cases there is sufficient balance for a water-wash.

Filter-press dewatering is practiced at the Homestake, Great Fingall, and elsewhere, and illustrates the most exact precision of chemical manipulation. The ore is first amalgamated to reduce coarse-gold content and the subsequent cost of chemical treatment by cyanide. It is thoroughly washed during milling, and lime is added previous to cyaniding to counteract soluble refractories and to assist coagulation. Cyanide treatment is then carried out in the presses on a neutralized slime, and unnecessary exposure to atmospheric influences is avoided, the time of cyanide treatment being limited to a minimum. The result is an extraction and recovery unparalleled in the metallurgy of gold ore and a cyanide consumption well below the average.

With ordinary chamber filter-presses a low percentage of moisture is left in the residue, from 15 to 25 per cent; but where opportunity permits an extensive water-wash it is often advisable to dispense with its use. It has been found that the practice necessitates a much higher cyanide strength than is necessary for the effective solution of the gold; and the loss of cyanide when an appreciable percentage of the moisture in the residue is in the form of barren solution is less than when an attempt is made to retain the whole of the solution, plus the contained double salts, in the circuit. In other words, a reduction in cyanide follows the practice of keeping the zinc content in the solution as low as possible; and the simplest way to insure this is to discharge a small percentage of the solution with the residue as moisture.

With regard to the use of a replacement water-wash with a filter-cake there are few instances where this is practicable. In most cases the time may be better employed in extending the solution-wash. Water will only mechanically displace dissolved gold, but the use of solution may cause residual gold to dissolve as well as replacing gold already in solution. There is also no danger of upsetting the chemical equilibrium of the solution by dilution.

When the residue is being discharged at a high percentage of moisture a final and efficient water-wash is, of course, imperative. Under normal conditions, however, the retention of practically all the solution in a closed circuit, with the constant addition of zinc and other impurities, will eventually result in an increased chemical consumption, and a decrease in actual recovery.

Questions of Acidity and Alkalinity

A great number of ores have an acid reaction. This acidity should be neutralized before the ore is brought into contact with cyanide solution, more especially if the latter contains gold. This neutralization can be effectively carried out by the adoption of milling in water. If milling in cyanide is practiced there is a loss of solvent from this cause alone which is by no means insignificant when circumstances prevent a high alkalinity being maintained in the solution.

On the question of the degree of alkalinity it is common knowledge that, in the great majority of cases, the amount of electrolyte needed for effective settlement involves a higher alkalinity than is good for satisfactory and economincal precipitation. In other cases a very low alkalinity is required for effective solution of the metal in cyanide. When milling and thickening in cyanide solution is practiced it is generally found that the question of alkalinity for solution and precipitation of the gold must be subordinate to the degree required for effective settlement of the ore. Under these conditions, and especially in the case of an ore carrying a variable clay or schistose content, it is almost impossible properly to control the alkalinity to suit metallurgical requirements without interfering with the mechanical capacity of the settling plant. On the other hand when milling in water is practiced a fairly high alkalinity can usually be maintained in the milling circuit with its attendant advantages of improved amalgamation, more effective settlement of the slime, and a clearer overflow for battery-water service. At the same time a thicker discharge can be obtained from the dewaterers. On account of the lower water percentage in the thickened sludge the resultant alkalinity of the pulp, after having been thinned with plant solution, is so low that alkalinity control is then an easy matter, and can be adjusted to a nicety to suit metallurgical and chemical requirements.

These remarks with reference to latent acidity in the ore also apply to the numerous instances where the ore contains reducing agents, raw or partly oxidized pyrites, or other compounds whose detrimental effects on a cyanide salt, or on a solution of metals of uncertain stability, would be wholly or partly neutralized by the preliminary treatment with lime or other alkali. In the case where the available water is acid or naturally impure, the cost of preliminary treatment may often be avoided by milling in lime-water; and a number of the troubles encountered from such a source may be overcome by the addition of sufficient alkali in the battery.

Disadvantage of Large Volume of Metal-Bearing Solution

A further disadvantage of milling in cyanide lies in the fact that the necessary quantity of metal-bearing solution must be very largely increased, and accurate control rendered more difficult. The metal in the battery solution can only be reduced by an increase in the tonnage precipitated, involving further consumption of cyanide and zinc. If the practice of milling an acid ore in a cyanide solution carrying an appreciable quantity of metal is to be avoided, then all the solution coming from the mill should be precipitated. When sliming follows milling it is often difficult, if not unwise, to keep the dilution below 1:10; and the latter figure multiplied by the tonnage would possibly underestimate the amount which ought to be precipitated. In general practice, however, a compromise is usually effected. A part of the solution is precipitated, and the possible ill-effects of bringing the remainder of the dissolved metal in contact with raw ore is not taken into account. The result is in favor of premature precipitation, colloidal absorption of dissolved gold, and a decrease in the net recovery in the plant.

The loss of cyanide due to the necessity of bringing moisture in the crushed ore up to general average cyanide strength has been estimated on the Rand to amount to 0.12 lb. (KCN) per ton of ore. But as the total cyanide consumption on this field, where milling in water is almost entirely practiced, amounts to 0.3 lb. per ton, it is obvious that there are economical advantages in favor of milling in water which greatly outweigh the loss of cyanide from the above cause.

The restricted limit to cyanide operations as a result of milling in water is doubtless responsible for the very low average cyanide consumption; and recent experiments have shown that this could be halved by minimizing the contact of cyanide solution with the air, i. e., by closing-in the plant.

Chemical and Mechanical Loss of Cyanide

In milling-in-cyanide practice the exposure of large tonnages of solution to deleterious atmospheric effects, accompanied as it is in many cases by violent agitation in milling apparatus, is also responsible for considerable chemical loss of cyanide due to the evolution of hydrocyanic acid—a gas whose presence is not difficult to detect in many plants.

As regards chemical loss of cyanide J. W. Hutchison[1] stated that, with reference to Goldfield Consolidated results, a marked increase was indicated by adopting milling in cyanide, the conclusion being confirmed by a three-weeks' test. W. P. Lass also stated,[2] in connection with the preliminary work with Alaska Treadwell ore, that previous agitation with alkali saved 25 per cent of the cyanide consumption. E. M. Hamilton has shown that,[3] in treating a concentrated pyritic material, direct cyanidation caused a loss of 100 lb. of

[1] Eng & Min Jo... V... p. 17...
[2] Min. & Sci. Pre... ...1911
[3] Eng & Min. Jour. V... p. 84...

the solvent per ton, an amount subsequently halved by preliminary treatment with lime-water.

Mechanical loss of cyanide when milling-in-water is practiced is largely influenced by the effectiveness of the dewatering equipment. On the other hand an almost complete displacement of the cyanide solution from the residue may result in fouling, which necessitates a higher cyanide strength in the solution and a greater cyanide consumption than would otherwise occur.

As a matter of fact some misconception exists with regard to this question. Complete displacement of solution by water in a final wash is seldom or never practiced, and in the great majority of instances is impossible to obtain. The amount of solution ultimately discharged with the residue is, more or less, in inverse ratio to the time spent in water washing, as compared with the time spent in solution washing. In other words if it takes an hour to displace rich solution in a thick cake with barren solution, it will also take an hour to displace the barren solution with water. A five or ten-minute water-wash generally suffices, so that the operator of a leaf vacuum-filter is probably discharging more solution with his residue after a water-wash than a filter-press operator would discharge after solution washing only. If it is admitted that a certain percentage of solution is invariably discharged with the residue, which I think is incontestable, then it is obvious why fouling of solution is more in evidence where milling in cyanide is practiced. With milling in water the solution is more easily controlled and the "barren," with the highest zinc content, is used almost in its entirety for washing after filtration. Hence the largest amount of zinc is sent to the dump in the smallest amount of solution. Where milling in cyanide is practiced a very large proportion of the "barren," containing the highest zinc content, is sent back to the main circuit and distributed over a large bulk of diluent.

The statements which are made as regards loss of cyanide as a result of milling in water are not borne out in practice and the majority of operators whose experience has included both methods with a variety of ores will probably agree that the advantages of a preliminary alkaline treatment by milling in water, the close control of the solution on account of the restricted amount, and the low tonnage to be precipitated, are all favorable factors insuring low cyanide consumption in the treatment of a gold ore.

Milling in Cyanide Increases Time of Treatment

As regards time of treatment both Mr. Hutchison and Mr. Lass, already quoted, make decisive statements that, in dealing with their respective ores, a longer time was required to effect solution when milling in cyanide was practiced. These results are coincident with my own, and a number of tests convinced me that the gold in mill solution, when brought into contact with fresh ore in a milling plant, was not of so stable a nature as is generally supposed. The tests indicated a great difference when the ore was cyanided after a preliminary alkaline treatment as compared to a similar handling of the residue from the milling-in-cyanide plant after complete treatment. In the latter case further solution from a comparatively high residue only occurred after protracted periods of agitation and then only in minute amounts, the rate of extraction being practically unaffected by replacement of solution. On the other hand when the orginal ore was agitated direct after a preliminary alkaline treatment a lower residue was obtained in a very much shorter time.

As facilities for mechanical contact between ore and solvent are far more favorable when cyaniding is commenced in the mill it is probable that this apparent delay in the dissolution of the gold is really due to the fact that absorption, adsorption, and possibly re-precipitation of the metal accompanied its solution by cyanide. It may be assumed that the final "extraction" point is delayed until the re-precipitated or absorbed gold has been re-dissolved; and also until as much as possible of the absorbed metal-bearing solution has been osmotically removed by continued contact with a solution of different strength. These final phases would be slow-acting processes and the theory may account for the apparent delay in the extraction of gold from ore after it has been milled in a cyanide solution containing gold.

Effect on Gold Recovery

With regard to the question of gold recovery percentage by both methods Mr. Hutchinson stated that, at Goldfield, crushing in alkaline water followed by cyanide treatment resulted in an increase of two per cent in the extraction, as against milling in cyanide. On the other hand, and dealing with the case of an amalgamable gold ore, the loss in actual recovery would be proportionate to the amount of gold which could have been extracted by amalgamation.

The Alaska Treadwell tests showed equal extractions with straight cyanidation as compared with cyanidation preceded by amalgamation; from which it may be deduced that practical methods would favor the inclusion of the latter process if net recovery only was taken into consideration. The final conclusion, however, is generally dependent on a number of other factors which might deflect the decision in favor of milling in cyanide.

Further complications arise in the matter of the clarification of the solutions where milling in cyanide is practiced. Clarification may often be effected with a sand filter after milling in water. The finely divided colloid which is in so many instances a feature of the solution after milling in cyanide may be coagulated by using excess of lime. Under such conditions the degree of alkalinity which it is necessary to maintain in the solution has a prejudicial effect on precipitation.

Efficient Sampling Favors Milling in Water

In the matter of sampling any decision will be overwhelmingly in favor of milling in water, since the efficiency of the operation is proportionate to the fineness to which the ore has been ground before the sample is taken. This is borne out in assay practice, the assay charge from a sample being the logical equivalent of a sample from a day's run.

There are, of course, mills where an elaborate system of sampling is installed, and where a large proportion of the tonnage is handled and re-ground in the sampling plant. Under such conditions and even with an ore carrying a coarse or variable metal content a good average sample may be obtained, but its representative value is not comparable with a sample of the whole

product that is taken automatically after milling in water. The necessity for the efficient sampling of the ore in a mill cannot be overestimated, and a deal of unnecessary worry and not a little disappointment would be avoided if more attention could be paid to this detail in the first instance. Nothing is more detrimental to the efficiency of operations than the knowledge that no sure conclusions can be arrived at as to the results of the work being carried on, or any reliable forecast made from the assay results of samples of the ore.

Influence of the Personal Factor

Modern milling practice requires constant attention to details, such as the testing of the pulp at every stage of the reduction process. One deterrent factor in cyanide mills is seen in the trouble caused to operators by the poisonous effects of the solution in circuit. I have encountered three classes of millmen. One of these was immune, and obviously so, from any ill-effects. The second class protested an immunity but took particular care, I noticed, to avoid exposure whenever possible. The third class made no pretence and maintained that unless they took special precautions and often avoided a necessary duty they suffered in no light degree. It is impossible to keep one's hands dry in a wet-milling plant although subsequent cyaniding operations may be efficiently controlled by methods involving the minimum of personal discomfort to the operator, and often with an entire avoidance of contact with solution.

In deciding on a process by a comparison of figures the personal factor is often overlooked; and, unless the millmen selected happen to be in the enviable minority and immune from infection, a serious factor against efficient working is encountered by the adoption of milling in cyanide. Infection may result in symptoms varying from slight rash annoyance to perpetual irritation by day and insomnia by night; and the superintendent must often withhold censure for neglect of duty when he knows that vigilance on the part of the millman would have resulted in increased personal discomfort.

The outstanding features of milling in cyanide may be summarized as follows:

Advantages

(1) The milling and regrinding plant offers exceptional advantages for the solution of gold and silver by reason of the intimate contact between metal and solvent.

(2) A saving in water consumption may be effected by milling in cyanide in cases where the settlement of the ore is difficult; where the dewatering units are ineffective; or where the residue is being discharged at under 20 per cent moisture.

(3) A simplification of plant arrangement is possible and separate return-pumping and storage systems for solution and water are unnecessary.

Disadvantages

(1) Decrease in amalgamation efficiency where this recovery method is practiced; corrosion of plates; and increased consumption of mercury.

(2) Higher cyanide consumption and longer time required to effect a lower extraction of the metal in the ore.

(3) Increase in the amount of metal-bearing solution in circuit, with greater liability for mechanical loss; and proportionately higher precipitation costs per ton milled.

(4) Liability of neglect in milling and grinding plant operation on account of the poisonous nature of the diluent.

Applicability

(1) When no advantage, either economical, metallurgical, or chemical, arises from the use of a preliminary alkaline treatment of the ore or the water used for milling purposes.

(2) When amalgamation, if adopted, would result in an inappreciable saving.

(3) When it is not necessary to fine-grind or slime the ore preparatory to cyanidation, thus obtaining a product which, in residue form, usually contains more moisture than if coarser crushing, followed by leaching, had been adopted.

(4) When dewatering prior to cyaniding, to within a few percentages of the amount of moisture to be discharged in the residue, is impracticable.

Probably no other phase of any chemical-metallurgical process is being operated under so many different conditions as the one dealt with in this article; and for this reason an effort has been made to avoid dogmatic decisions. The conclusions are based on many data and observations of practical operations under an immense variety of conditions with an extensive amount of experimental research, coupled with the available information on the subject.

The necessity for the marshalling of facts and the classification of ideas on this important development is obvious. The subject of milling in cyanide has been barely mentioned even in recent text-books; and the method has often been adopted as a necessary concomitant in the utilization of a specialized process of solution recovery, and sometimes without an apparent realization of the advantages in favor of the alternative method of milling and thickening in alkaline water as a preliminary to cyanide treatment.

New York, N. Y.

Technical Association of the Pulp and Paper Industry Meets at Dayton, Ohio

The annual Spring meeting of the Technical Association of the Pulp and Paper Industry will be held in Dayton, Ohio, May 16 and 17, 1918. The particular subject for discussion at the technical sessions is Fuel Economy and Scientific Boiler Room Methods. This subject is of particular importance in connection with the operation of paper mills and it is expected that much information will be brought out for the benefit of the industry. The paper manufacturers of the Miami Valley have arranged for the entertainment of the Association and for the inspection of several of the important paper mills. The meeting is considered important on account of the probable shortage of fuel for paper mills next winter and the necessity of curtailing operations.

Proposed Iron and Steel Works for Queensland, Australia.—The British Board of Trade Journal says that a Royal Commission appointed in 1917 reports that a great deal of research work must be done, and much more information be collected before they can make recommendations with regard to the establishment of a complete iron and steel works. They say, however, that all the essentials are in Queensland for the successful manufacture of pig iron, and that an experimental plant for its manufacture can and should be established (costing roughly $25,000) to test in bulk the available iron ore deposits and to determine the proper site for an eventual iron and steel works. They also believe that the making of pig iron would be a profitable undertaking for the state.

Washing in Filter Presses

By D. R. Sperry

Simple Washing, Recessed Type, Separate Inlet and Outlet For Wash

There are certain cases in which it is desirable to have the wash-water connection on the filter-press separate and distinct from that of the feed connections. This can be accomplished in the recessed type only with the use of frames. It would be possible of course to put in a duplicate feed-channel composed of a separate set of grommets but such an arrangement is rather too expensive and impractical to be employed. When frames are used a channel is formed by placing an eye in the upper corner opposite the one occupied by the grommet. In Fig. 1 a recessed plate-and-frame filter-press having separate inlet and outlet connections for simple washing is shown in two cross-sections.

The upper cross-section shows that the material to be filtered when introduced into the feed-inlet traverses the entire length of the filter-press passing from frame

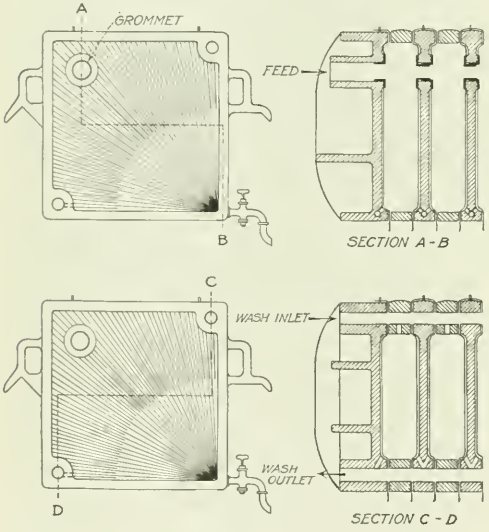


FIG. 1.

to frame by way of the openings through the grommets. The chambers bounded by the frames and filter-base, usually canvas, are thus filled with the material to be filtered, the liquid passing through the filter-base and deposited solids on to the surface of the plate and out of the filter-press via the cocks. The solids are allowed to deposit only until there is still an opening between the solids on either chamber wall. The feed is then shut off and the cocks closed. Wash-water is then admitted into the separate wash-water channel.

The lower cross-section taken through the wash-water inlet and outlet channels shows that the wash-water runs the entire length of the filter-press dropping into each frame by means of the port in the eye of each frame. The wash-water thus brought into intimate contact with the deposited solids, passes through them, against the plate surface and out, not through the cocks as the filtrate did, but through the port in the opposite corner. The ports feed into the wash-water outlet formed by the eyes in the lower corner. The issuing wash-water is thus led to the outside of the filter-press at the point called the wash-water outlet. The frame used in this arrangement is shown in Fig. 2. A photograph of a plate belonging to this system is shown in Fig. 3. For the filtering and washing of certain materials this arrangement is a very convenient one. The

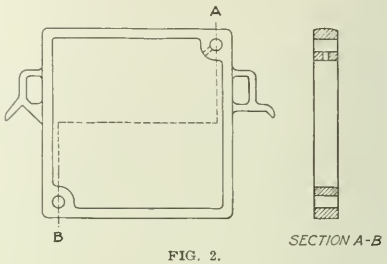


FIG. 2.

feed-channel formed by the openings in the grommets makes a very generous feed opening suited to heavy materials. The fact that the wash-water has its own entrance and exit permits the use of permanent connections and allows the washing to be carried on independent of the filtering process.

Simple Washing, Flush Plate, Separate Inlet for Wash

In the flush type of plate without grommet feed, simple washing may be carried on having a separate inlet for the wash-water. Such an arrangement is shown in cross-section in Fig. 4. The frame alone is shown in Fig. 5. The upper cross-section indicates that the feed-inlet channel formed by the eye in the corner diagonally opposite the cock, leads the material to be filtered directly to the interior of each frame. Here as in the preceding

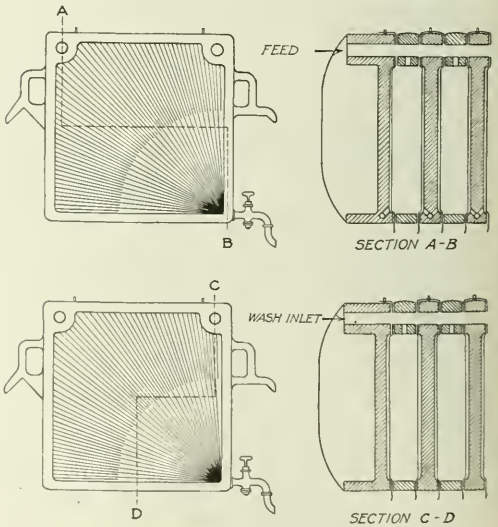


FIG. 4.

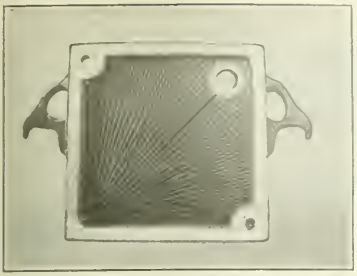


FIG. 3.

FIG. 11.

case the solids are allowed to build up on the sides of the chamber, usually cloth, only until the two walls of solids still leave an open space between them. The feed is then shut off and wash-water admitted into the wash-water channel.

The lower cross-section shows that the wash-water is conveyed to the open spaces left in the chambers by means of the channel formed by the eye opposite the feed eye. The wash-water passes through the solids against the surface of the plate and out by way of the cocks, precisely as the filtrate did. A view in a filter-press having this arrangement is shown in Fig. 6. The filter-press is opened to show the eyes and is not clothed. In Fig. 7, a photograph of a filter-press showing the head connections as they appear in this arrangement is shown. This type of filter-press is used where the material to be filtered does not bear solids which have a tendency to clog up small openings. The hole connecting the feed-channel with the interior of the frame is ordinarily quite small, hence, it is unwise to use a filter-press of this kind upon heavy materials. An exception to this rule is the case in which the frames are of such thickness that a fair sized port running to the feed-channel is practical.

Simple Washing, Flush Plate, Separate Inlet and Outlet for Wash

In practice it is often inconvenient to have the wash-water follow the same path as that taken by the filtrate. It is sometimes very necessary to allow no liquid other than the filtrate to come in contact with the cocks or gutter. In such a case a separate outlet for the wash-water must be provided. This can easily be done and arrangement for this purpose is shown in cross-section in Fig. 8. As in the case just given, the upper cross-section shows that the material to be filtered reaches the interior of each frame by means of the channel formed in the upper left-hand corner. When the cake on each side has been deposited only enough to have an open space down the center of the chamber, the feed is shut off and the cocks on each plate and head closed. Wash-water is then admitted into the wash-water channel, shown in cross-section in the lower part of Fig. 8. It can be seen that the wash-water reaches the open spaces left in the centers of the chambers by means of the wash-water port in the corner of the frame.

A separate frame in cross-section is shown in Fig. 9. The wash-water passes through the solids and emerges against the surfaces of the plates. It cannot leave the plate via the cocks, which are closed, as did the filtrate, but it does leave the plate by means of the port in the opposite corner which leads it into the wash-water outlet channel formed by the eyes in the lower left-hand corner. In this manner the wash-water both enters and leaves the filter-press without coming into contact with the cocks or gutter. The connections can be made permanent and the wash-water led to any desired place. In Fig. 10 is shown a photograph of a filter-press arranged as last described. Fig. 11 shows a picture of a separate plate used in this arrangement.

Closed Discharge for Filtrate

In any of the foregoing cases the filtrate may be caused to issue from a single connection in the fixed head, thus dispensing with cocks on each plate and head. This is called "closed discharge." In such a case there is placed an eye in the corner where a cock would otherwise be placed. This forms a channel the entire length of the filter-press. The drainage from the plates runs into the channel through ports running from the eye to both surfaces of the plate. This is often used where it is undesirable to allow the filtrate to come in contact with the atmosphere, or where it is desirable to elevate the filtrate to a level higher than that of the filter-press.

Simple Washing in General

In actual practice one does not find many filter-presses using simple washing. There are several objections to it and in the majority of cases the other kind of washing, known as thorough washing, to be described later, is preferable. In the first place it is an exceedingly diffi-

FIG. 6.

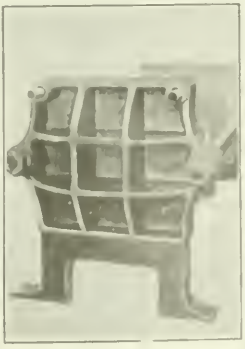


FIG. 7.

FIG. 10.

cult matter when handling the usual mixtures of solids and liquids to stop the filling operation at that point in which the adjacent cake walls are not yet touching each other. If all the conditions were precisely the same during each fill this system would be much more in use today than it actually is. The time allowed for filling is no criterion unless the conditions are always the same. It is very seldom that the per cent of solids and their other physical properties are the same each fill. If they vary, then the filling time varies and the cake walls will either touch each other, causing poor washing, or they will be unnecessarily far apart decreasing the capacity of the filter-press. The pressure under which filtration is carried on is seldom exactly the same, due to different pump speeds, different operators, etc., making still another factor likely to cause trouble. The temperature will vary to a certain extent reducing the viscosity and changing the rate of deposition, making a third variable.

In order to secure the same capacity for solids as in the case of thorough washing where the chambers are allowed to fill completely, it is necessary that the chambers be made thicker or that the capacity for solids be decreased. It is a matter of common observation and of fact, that the cake on the walls of the filter-press chambers forms thicker at the bottom than at the top. This is due to the effect of gravity on the solids which are being deposited. This means that if the wash-water is to reach all parts of the cake, it is necessary to stop the filling operation while the thicker bottom portions are still apart requiring a frame or chamber thicker than would be the case were the cake uniform in thickness. If this is done it can readily be seen that the upper or thinner part of the cake wall will be more thoroughly washed than the lower and thicker portion.

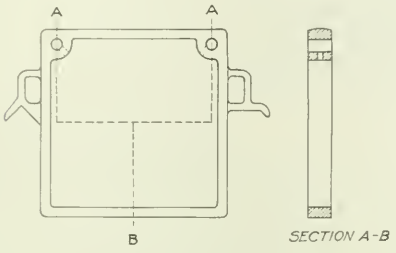


FIG. 5.

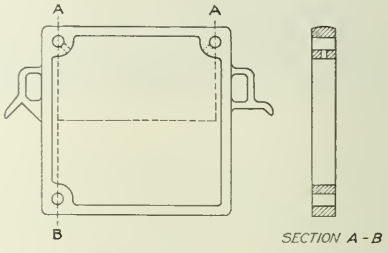


FIG. 9.

Simple washing is used most effectively in the case of finely divided substances which in a reasonable filling time form a very thin cake. In such a case, thorough washing is almost out of the question if the chambers are of much thickness, while by the use of simple washing all parts of the cake are very thoroughly washed. In finely divided substances the effect of gravity tending to make the cake walls of variable thickness is small, which is a point in favor of simple washing for this class of mixtures.

Batavia, Ill.

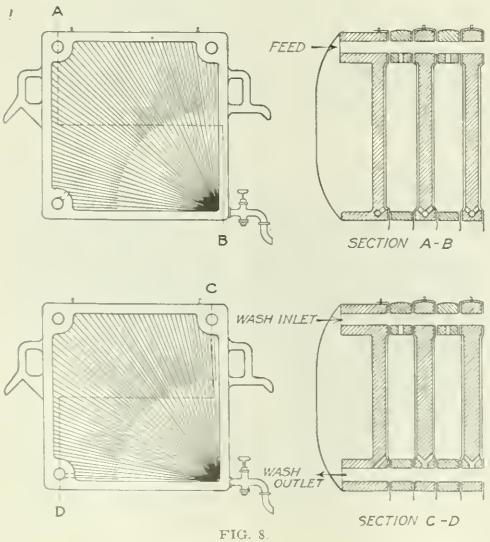


FIG. 8.

Potash Exploration.—Secretary of the Interior Lane has approved working instructions and regulations under the potash leasing act of Oct. 2, 1917, a matter which has been given the most careful consideration, in view of the importance attached to this pioneer work in the development of a great national asset. The act is liberal in its terms, authorizing the exploration for and disposition of potash deposits generally in the public lands of the United States, undea system that provides for a preliminary permit to the holder for the exclusive privilege of searching for deposits of potash for a period of not exceeding two years. The acreage embraced within one permit is limited to $2560 acres, and the Secretary, upon a satisfactory showing that valuable deposits of potash have been found within the permit, is authorized to issue a patent to not exceed one-fourth of the amount covered by the permit, the remaining lands in the permit being subject to lease either by the permittee or others, after advertisement, competitive bidding, or such other methods as the Secretary may by general regulations adopt. To the end, therefore, that the liberal purposes of the act may find the fullest scope of operation, the instructions and regulations now approved, are broad in outline, simple in form, yet so directly addressed to the matter in hand that it is believed all applicants under the law will find but little difficulty in presenting their claims for consideration by the Department. Requests for copies of these instructions should be addressed to the Commissioner of the General Land Office, Washington, D. C.

Annealing and Recrystallization of Cold-Rolled Aluminium Sheet

By ROBERT J. ANDERSON

THE present article gives the results of a series of tests made on the effects of heat at different temperatures on the softening of cold-rolled sheet aluminium; similar results, other than the late paper by Carpenter and Taverner,[1] so far as is known, have not hitherto appeared in the technical press. The common practice employed for annealing cold-rolled sheet aluminium is to heat the metal for a long period of time, say 18 to 30 hours at a temperature of approximately 375 deg. C. The annealing is carried out in large furnaces of the gas or oil-fired types, under pyrometric control, and upon completion of the anneal the metal is withdrawn and allowed to cool in air. Cold-rolled aluminium so heat-treated is very soft and pliable—the Shore scleroscope hardness being about 4 to 5. The aluminium referred to is first-grade metal analyzing 99 per cent Al and over, and with the impurities Si, Fe, Mn, and Cu in subordinate amounts. Experiments (not described in this article) have been made by the writer which showed that hard-worked, i.e., cold-rolled, aluminium can be softened to 4 or 5 Shore scleroscope hardness-number by short time exposures at temperatures near 375 deg. C. A description of the tests carried out on a variety of gages of cold-rolled aluminium sheet follows.

A chill-cast aluminium ingot was heated to 455 deg. C. in an ingot-heating furnace, and remained in the furnace approximately six hours before rolling. The analysis of this metal was as follows:

	Per Cent.
Cu	0.25
Fe	0.45
Mn	trace
Si	0.35
Al (by diff.)	98.95

The ingot was broken down hot in a two-high breakdown mill to a slab whose dimensions were, 0.2291 in. x 40 in. x random; the reduction of the ingot, whose approximate dimensions were, 4 in. x 12 in. x 17 in., to the slab of the size given was accomplished by five or six passes in the mill. The slab so made was allowed to cool to room temperature; it was then slabbed cold to 0.1215-inch thick, and was then rolled to a succession of gages as follows: 10, 12, 14, 16, 18, 20, 22, 24, 26 and 28. The separate gages were all obtained from the same slab by rolling the slab to 10 gage, then shearing off a section, then rolling the remainder to 12 gage, shearing off a section, and so on until the range of gages mentioned was obtained. Sufficient metal of each gage was obtained to furnish samples for the annealing tests. In annealing, the time and temperature were varied over a wide range, as is shown in the accompanying tables, but the aim in general was to produce a softening to 4 or 5 Shore scleroscope number—this being considered maximum softness from the standpoint of practical mill operation. Annealed aluminium, however, at times may give a lower scleroscope reading.

[1]Carpenter, H. C. H. and Taverner, I. The Effect of Heating at Various Temperatures on the Rate of Softening of Cold-Rolled Aluminium Sheet; Paper before the Inst. of Metals (London), Fall, 1917; and in Engrg. (London), vol. 104, 1917, No. S., p. 212.

Relation of Hardness and Ductility

Hard-worked aluminium sheet will have a scleroscope hardness ranging from 13 to 15, and in the hard-worked condition the metal cannot be drawn into shapes in the draw press. In the annealed condition, the scleroscope hardness will be 4 to 5; semi-annealed or "half-hard" sheet aluminium has a scleroscope hardness of from 7 to 11, depending upon the annealing period or the number of passes through the rolls. Thus a "half-hard" sheet may be produced by a partial anneal upon a cold-rolled sheet, or by giving an annealed sheet a few passes through the rolls of a finishing mill. An annealed sheet whose scleroscope hardness is 4 to 5 may possess maximum ductility or very little depending upon the period of annealing and the temperature. For instance, if a given cold-rolled sheet be annealed for say 30 hours at 400 deg. C., its scleroscope hardness will be about 4, but it will be in a weakened condition and possess a relatively large grain size; on the other hand, if the same metal be annealed for 10 minutes at 400 deg. C., its scleroscope hardness will also be about 4, but it will be much stronger and have a smaller grain size than the first-mentioned sheet. For drawing, bending, and shaping operations on aluminium sheet, it is necessary that the metal have the maximum ductility which can occur together with a scleroscope hardness of 4 to 5.

Annealing Experiments On Aluminium Sheet

In Table I, are given the results of tests made on the original hard sheets as they came from the mill. The ductility values were obtained with the Erichsen ductility testing machine for sheet metal, and hardness was taken with the Shore scleroscope. Percentages of reduction on the various gages of sheets were calculated according to formula, using 40 inches as the constant width, and starting from the 3-gage slab. Table II gives the percentages of reduction as calculated from the formula.

$$\frac{\text{Original area} - \text{final area}}{\text{original area}} \times 100 = \text{per cent reduction}$$

Annealings were made on all the different gages mentioned above, employing different times and temperatures, for the purpose of fixing the softening range of the metal for a given amount of deformation, i.e., percentage of reduction. Scleroscope hardness numbers were used to indicate softenings, and Erichsen tests were made when desirable. The results are given in Tables IV to XIV inclusive. There was a measurable

TABLE I. ERICHSEN AND SCLEROSCOPE VALUES FOR THE HARD SHEETS

Mark	Sheet Gage	Scleroscope Hardness	Thickness in Millimeters	Indentation in Millimeters	Measured Thickness in In. by Micrometer
1	3	5 0	5 96	. . .	0 2291
2	8	12 5	3 11	. . .	0 1215
3	10	14 0	2 58	10 01	0 1037
4	12	15 0	2 05	9 49	0 0841
5	14	15 0	1 70	8 24	0 0650
6	16	15 5	1 32	7 28	0 0512
7	18	15 0	1 02	6 58	0 0401
8	20	15 0	0 79	6 16	0 0321
9	22	15 0	0 68	5 92	0 0275
10	24	14 5	0 54	5 16	0 0220
11	26	15 0	0 40	4 57	0 0169
12	28	13 5	0 30	3 64	0 0128

NOTE.—The figures given represent the mean of closely agreeing determinations.

TABLE II. PERCENTAGES OF REDUCTION OF HARD SHEETS

Mark	Sheet Gage	Measured Thickness in In.	Percentage Reduction
1	3	0.2291	. . .
2	8	0.1215	47.00
3	10	0.1037	54.85
4	12	0.0841	63.30
5	14	0.0650	71.60
6	16	0.0512	77.70
7	18	0.0401	82.60
8	20	0.0321	86.00
9	22	0.0275	88.00
10	24	0.0220	90.50
11	26	0.0169	92 70
12	28	0.0128	94.50

NOTE.—There is some difference in the measured thickness of the sheets in inches compared to the measured thickness in millimeters (from the Erichsen tests) calculated to inches due to variation in the thicknesses of the sheets and the fact that the measurements were made at different points on the sheets, but these differences do not vitiate the results.

TABLE III. SHOWING VARIATIONS IN THICKNESSES OF SHEETS

Mark	Sheet Gage	Measured Thickness in In.	Measured Thickness in Millimeters	Calculated In. from Measured Millimeters	Calculated Millimeters from Measured In.
1	3	0.2291	5.96	0.2384	5.73
2	8	0.1215	3.11	0.1244	3.04
3	10	0.1037	2.58	0.1032	2.59
4	12	0.0841	2.05	0.0820	2.10
5	14	0.0650	1.70	0.0680	1.63
6	16	0.0512	1.32	0.0528	1.28
7	18	0.0401	1.02	0.0408	1.00
8	20	0.0321	0.79	0.0316	0.80
9	22	0.0275	0.68	0.0272	0.687
10	24	0.0220	0.54	0.0216	0.55
11	26	0.0169	0.40	0.0160	0.42
12	28	0.0128	0.30	0.0120	0.32

TABLE IV. EFFECTS OF ANNEALING 10-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 54.85

Mark	Time in Minutes	Temperature Deg. C.	Scleroscope Hardness	Indentation in Millimeters	Appearance of Domes
3M	120	200	10.2	. . . .	. . . . .
3A	10	300	10.0	. . . . .	. . . . .
3B	30	300	7.0	12 20	. . . . .
3C	60	300	5.0	12.60	Coarse
3E	30	350	5.0	12.54	Medium
3N	5	400	10.6	. . . .	. . . . .
3G	10	400	5.0	12.12	Coarse
3H	30	400	4.8	12.32	Coarse
3I	60	400	4.5	11.75	Coarse
3J	10	600	4.0	10.90	Very coarse

variation in the thickness of the sheets at different points on their surfaces; and the measured thickness in inches by micrometer, the measured thicknesses in millimetres from the Erichsen test, the calculated inches to millimetres, and the calculated millimetres to inches are summarized in Table III. The annealings were carried out in a small laboratory electric furnace of the resistance type, and the temperatures given are accurate to ± 5 deg. C. The samples were cut from the various gages to a size of 3 in. x 10 in., thereby providing sufficient surface for three Erichsen tests and scleroscope hardness tests.

Appearance of the Annealed Samples

Blisters began to be apparent on samples marked F, which were annealed for 60 minutes at 350 deg. C.; sheets marked G, annealed for 10 minutes at 400 deg. C. showed small blisters in all gages, as did those

TABLE V. EFFECTS OF ANNEALING 12-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 63.30

Mark	Time in Minutes	Temperature Deg. C.	Scleroscope Hardness	Indentation in Millimeters	Appearance of Domes
4M	120	200	11.6	. . . . .	. . . . .
4A	10	300	10.6	. . . . .	. . . . .
4B	30	300	7.1	10.97	. . . . .
4C	60	300	4.9	11.70	Coarse
4K	20	350	5.0	11.93	Medium
4E	30	350	5.0	12.20	Coarse
4F	60	350	5.0	11.70	Coarse
4N	5	400	10.6	. . . .	. . . . .
4G	10	400	4.9	11.41	Coarse
4H	30	400	5.0	11.27	Coarse
4I	60	400	4.6	11.06	Coarse
4J	10	600	4 4	10.51	Coarse

TABLE VI. EFFECTS OF ANNEALING 14-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 71.60

Mark	Time in Minutes	Temperature Deg. C.	Scleroscope Hardness	Indentation in Millimeters	Appearance of Domes
5M	120	200	10.0	. . . . .	. . . . .
5A	10	300	10.6	. . . . .	. . . . .
5B	30	300	8.1	10.35	. . . . .
5C	60	300	4 9	11.51	Coarse
5K	20	350	5.0	10.90	Medium
5E	30	350	5.0	10.84	Coarse (?)
5F	60	350	5.0	10.77	Coarse (?)
5N	5	400	12.5	. . . .	. . . . .
5G	10	400	5.0	10.68	Coarse (?)
5H	30	400	4.9	10.60	Coarse (?)
5I	60	400	4.7	10.32	Coarse
5J	10	600	4.1	9.75	Coarse

TABLE VII. EFFECTS OF ANNEALING 16-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 77.70

Mark	Time in Minutes	Temperature Deg. C.	Scleroscope Hardness	Indentation in Millimeters	Appearance of Domes
6M	120	200	10.7	. . . .	. . . . .
6A	10	300	11.0	8.83	. . . . .
6B	30	300	8.1	9.21	. . . . .
6C	60	300	5.4	10.75	Medium
6D	10	350	8.9	8.90	. . . . .
6Y	15	350	5.0	10.97	Smooth
6K	20	350	5.0	10.21	Medium
6E	30	350	4.9	10.70	Medium
6F	60	350	4.5	9.76	Medium
6N	5	400	13.4	. . . .	. . . . .
6G	10	400	5.0	9.68	Coarse
6H	30	400	4.9	9.82	Coarse
6I	60	400	4.8	9.68	Coarse
6J	10	600	4.1	9.55	Coarse

TABLE VIII. EFFECTS OF ANNEALING 18-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 82.60

Mark	Time in Minutes	Temperature Deg. C.	Scleroscope Hardness	Indentation in Millimeters	Appearance of Domes
7M	120	200	11.0	. . . .	. . . . .
7A	10	300	11.7	8.20	. . . . .
7B	30	300	9.0	8.45	. . . . .
7C	60	300	5.1	9.96	Medium
7D	10	350	10.1	8.35	. . . . .
7K	20	350	4.8	9.62	Medium
7E	30	350	5.0	9.98	Medium
7F	60	350	4.5	9.23	Medium
7N	5	400	13.1	. . . .	. . . . .
7G	10	400	4.9	8.80	Medium
7H	30	400	4.5	8.92	Coarse
7I	60	400	4.1	9.02	Coarse
7J	10	600	4.1	8.60	Coarse

marked H, I, J and N. The matter of blistering is somewhat uncertain, and the writer has obtained such contradictory results on aluminium that he would not care to speak with certainty at the present writing. The results of the tests under discussion show that the metal blistered in all gages when heated to 400 deg. C. for even short times, and that at 350 deg. C. blistering starts after annealing for 60 minutes. Blisters are more or less dependent upon the original cast metal—the gas contained being a function of the temperature and speed of pouring, and also probably upon the melting practice. Thus, it has been found that certain sheets blister while others do not when annealed at the same temperature and for the same length of time.

TABLE IX. EFFECTS OF ANNEALING 20-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 86.00

Mark	Time in Minutes	Temperature, Deg. C.	Scleroscope Hardness	Indentation in Millimeters	Appearance of Domes
8M	120	200	10 3		
8A	10	300	11 9	7 32	
8O	20	300	4 8	8 65	Medium
8B	30	300	4 8	8 75	Medium
8L	40	300	5 0	8 74	Medium
8C	60	300	4 7	9 42	Smooth
8D	10	350	10.0	7 40	
8K	15	350	4.6	8 60	Medium
8E	30	350	5 0	8 95	Smooth
8F	60	350	4 5	8 52	Smooth
8N	5	400	5.0	9 20	Smooth
8G	10	400	5.1	8 44	Medium
8H	30	400	4 3	8 47	Coarse
8I	60	400	4 5	8 45	Coarse
8J	10	600	4 2	8 26	Coarse

TABLE X. EFFECTS OF ANNEALING 22-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 88.00

Mark	Time in Minutes	Temperature, Deg. C.	Scleroscope Hardness	Indentation in Millimeters	Appearance of Domes
9M	120	200	10.4		
9A	10	300	12 0	7 04	
9O	20	300	6 0	8 25	
9P	25	300	4 9	8 35	Smooth
9B	30	300	5.0	8 40	
9L	40	300	4 9	8 35	Smooth
9C	60	300	4 6	8 60	Smooth
9D	10	350	5 0	8 75	
9K	15	350	4 6	8 30	Smooth
9E	30	350	4 8	8 39	Smooth
9F	60	350	4 6	8 24	Smooth
9N	5	400	9 0	7 12	
9G	10	400	4 5	8 28	Medium
9H	30	400	4 3	8 12	Coarse
9I	60	400	4.1	8 25	Coarse
9J	10	600	4 0	7 95	Coarse

TABLE XI. EFFECTS OF ANNEALING 24-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 90.50

Mark	Time in Minutes	Temperature Deg. C.	Scleroscope Hardness	Indentation in Millimeters	Appearance of Domes
10M	120	200	10.4		
10A	10	300	10 5	6 72	
10O	20	300	4 7	8 25	Smooth
10B	30	300	4 6	8 15	Smooth
10L	40	300	4 8	8 00	Smooth
10C	60	300	4 7	8 07	Medium
10D	10	350	8.1	7 01	
10K	15	350	4 7	7 84	Smooth
10E	30	350	4 4	7 95	Smooth
10F	60	350	4 5	7 95	Smooth
10N	5	400	7.0	6 79	
10G	10	400	4 6	7 74	Smooth
10H	30	400	4 2	8 05	Medium
10I	60	400	4.2	7 98	Medium
10J	10	600	4 2	7 65	Coarse

Other Annealing Experiments

A set of samples of all gages were annealed in a large mill furnace at 370 deg. C. for 24 hours, and the results of the tests are summarized in Table XIV. All the fractured domes of the Erichsen tests were extremely coarse, indicative of large grain size and poor drawing quality. Long-time annealings for cold-rolled aluminium sheet are very harmful and confer undesirable properties upon the metal. A number of re-annealings were made upon 18-gage cold-rolled sheet, and the results of the physical tests were comparable to those in Table VIII.

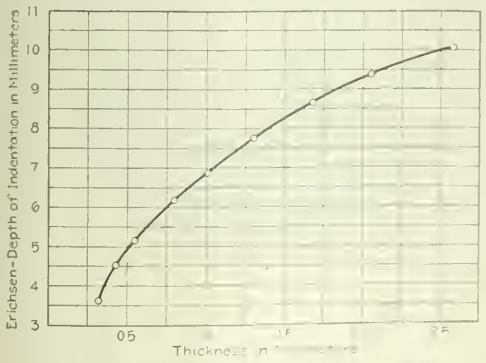


FIG. 1 THICKNESS—IDENTATION CURVE FOR COLD-ROLLED ALUMINIUM SHEET

TABLE XII. EFFECTS OF ANNEALING 26-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 92 70

Mark	Time in Minutes	Temperature Deg. C.	Scleroscope Hardness	Indentation in Millimeters	Appearance of Domes
11M	120	200	10 0		
11A	10	300	9 7	6 20	Smooth
11O	20	300	4 5	7 50	Smooth
11B	30	300	4 6	7 68	Smooth
11L	40	300	5 0	7 30	Smooth
11C	60	300	4 6	7 52	Smooth
11D	10	350	7 7	6 43	
11K	15	350	4 5	7 51	Smooth
11E	30	350	4 5	7 70	Smooth
11F	60	350	4 2	7 72	Smooth
11N	5	400	5 0	7 40	Smooth
11G	10	400	4 6	7 43	Smooth
11H	30	400	4 0	7 55	Smooth
11I	60	400	4 1	7 54	Medium
11J	10	600	4 1	7 27	Coarse

TABLE XIII. EFFECTS OF ANNEALING 28-GAGE COLD-ROLLED ALUMINIUM SHEET

Percentage of Reduction, 94 50

Mark	Time in Minutes	Temperature Deg. C.	Scleroscope Hardness	Indentation in Millimeters	Appearance of Domes
12M	120	200	10 1		
12A	10	300	9 9	5 30	
12O	20	300	4 6	7 31	Smooth
12B	30	300	4 5	7 52	Smooth
12L	40	300	4 9	7 15	Smooth
12C	60	300	4 8	7 35	Smooth
12D	10	350	7 1	6 90	
12K	15	350	4 1	7 35	Smooth
12E	30	350	4 8	7 33	Smooth
12F	60	350	4 3	7 15	Smooth
12N	5	400	6 0	6 93	
12G	10	400	4 2	7 16	Smooth
12H	30	400	4 3	7 40	Smooth
12I	60	400	4 2	7 42	Smooth
12J	10	600	4 0	6 96	Coarse

Curve Plots

In the case of cold-rolled aluminium sheet of a given gage, it is possible to make curve plots showing the time required for softening the metal to 4-5 Shore scleroscope number when employing various temperatures. The time for a given temperature depends upon the percentage of reduction of the cold-rolled sheet, and to a less extent upon its thickness. Fig. 1 is a thickness-indentation curve for cold-rolled aluminium sheet; indentation, as will be noted, varies with the thickness of the metal—heavier gages of sheets giving deeper indentations, other things being equal. Fig. 2 is a curve plotted from a set of composite results from the various tables (the figures were taken so that the Shore scleroscope number was 5 or below, and the

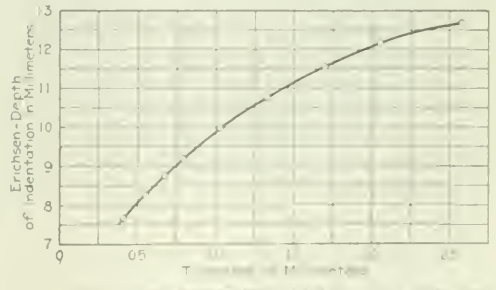


FIG. 2 THICKNESS—INDENTATION CURVE FOR ANNEALED ALUMINIUM SHEET

depth of indentation the highest for the shortest times and lowest temperatures, together with a smooth dome on the ruptured Erichsen test piece). The figures used were those in Table XV, and the curve shown in Fig. 2 may be taken as a correct thickness-indentation curve for annealed aluminium sheets for drawing purposes.

Microscopic Examination

Microsections were procured from most of the annealed samples, and the internal structure of the metal was examined for general characteristics, recrystallization, etc. The photomicrographs in Figs. 3 to 6 inclusive illustrate the effects of annealing 12-gage cold-rolled sheet which had been reduced 63.30 per cent in the cold. Fig. 3 is a photomicrograph of the original cold-rolled sheet; there is no evidence of crystallinity; grain boundaries cannot be discerned, and the metal is evidently mostly amorphous. The degree of deformation employed was large, and the structure of the metal is as would be expected. Fig. 4 illustrates the appearance of this metal after annealing for 60 minutes at 350 deg. C.; recrystallization has commenced but is far from complete. However, when annealed in the manner just mentioned, the metal was "dead" soft, even though recrystallization had not proceded very far. Fig. 5 shows the same metal after annealing at 400 deg. C. for 60 minutes, and recrystallization is still far from complete. Fig. 6 is the same metal after annealing at 600 deg. C. for 10 minutes: it will be observed from inspection of the photomicrographs that with a much shorter time but at a more elevated temperature that recrystallization has proceded further in Fig. 6 than

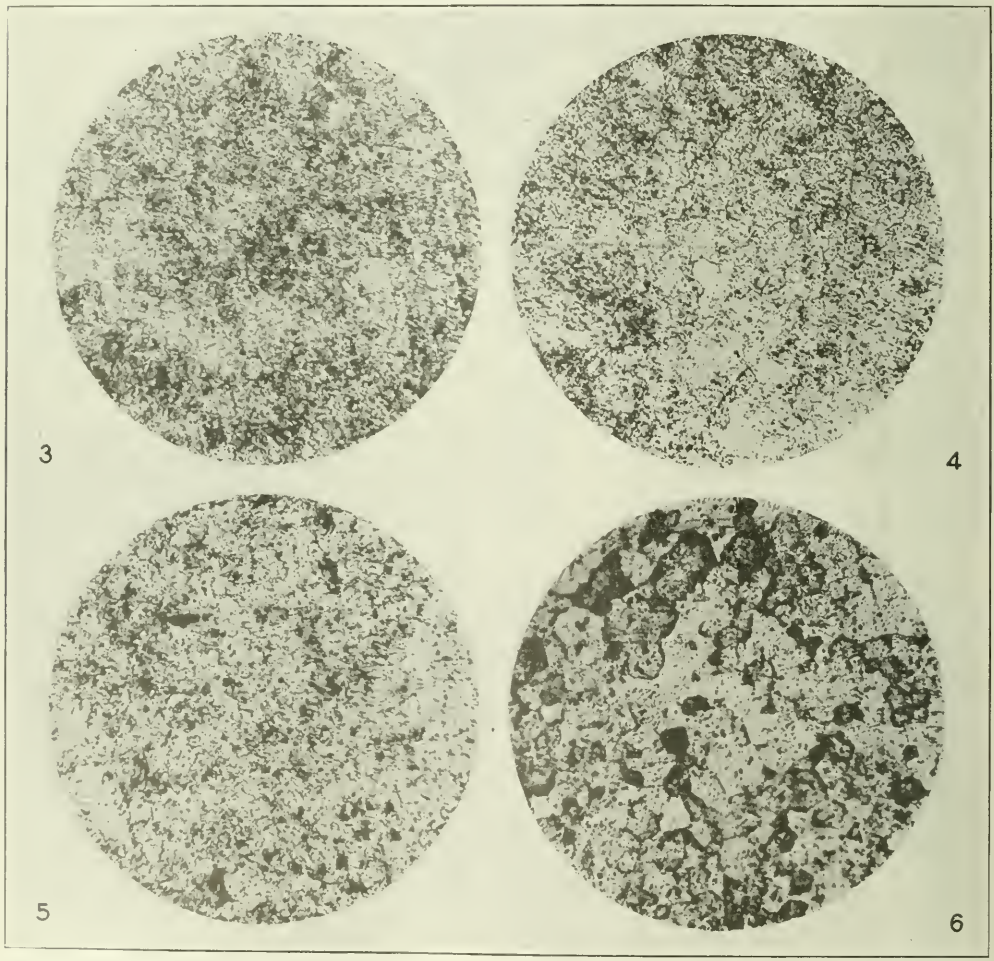


FIG. 3

Twelve-gage, hard-worked sheet; reduced 63.30 per cent in the cold; etched with HF; x 100 diameters.

FIG. 4

Twelve-gage sheet, after annealing, at 350 deg. Cent. for 60 minutes; etched with HF; x 100 diameters.

FIG. 5

Twelve-gage sheet, after annealing at 400 deg. Cent. for 60 minutes, etched with HF; x 100 diameters.

FIG. 6

Twelve-gage sheet, after annealing at 600 deg. Cent. for 10 minutes; etched with HF; x 100 diameters.

TABLE XIV. EFFECTS OF ANNEALING VARIOUS GAGES OF COLD-ROLLED ALUMINIUM SHEETS FOR 24 HOURS AT 370 DEG. C.

Mark	Scleroscope Hardness	Indentation in Millimeters	Appearance of Domes
3X	4 9	12 64	Coarse
4X	5 0	11 56	Coarse
5X	4 9	10 82	Coarse
6X	5 0	9 79	Coarse
7X	4 9	9 55	Coarse
8X	4 6	8 91	Coarse
9X	4 7	8 56	Coarse
10X	4 7	8 12	Coarse
11X	4 5	8 00	Coarse
12X	4 8	7 52	Coarse

TABLE XV DATA USED FOR THICKNESS-INDENTATION CURVE IN FIG. 2

Mark	Gage	Time in Minutes	Temperature Deg. C.	Scleroscope Hardness	Thickness Millimeters	Indentation Millimeters
3C	10	60	300	5 0	2 58	12 60
4E	12	30	350	5 0	2 05	12 20
5C	14	60	300	4 9	1 70	11 51
6X	16	15	350	5 0	1 32	10 97
7E	18	30	350	5 0	1 02	9 98
8E	20	30	350	5 0	0 79	8 95
9D	22	10	350	5 0	0 68	8 75
10D	24	20	300	4 7	0 54	8 25
11E	26	30	350	4 5	0 40	7 70
12B	28	30	300	4 5	0 30	7 52

TABLE XVI EFFECT OF DEFORMATION ON TIME OF RECRYSTALLIZATION

Mark	Gage	Per Cent Deformation	Microscopic Examination
3E	10	54 85	Not recrystallized
4E	12	63 30	Not recrystallized
5E	14	71 60	Not recrystallized
6E	16	77 70	Recrystallization commenced
7E	18	82 60	Recrystallization commenced

NOTE.—Samples marked E were all annealed for 30 minutes at 350 deg. Cent.

in Figs. 4 and 5. Recrystallization is still incomplete in Fig. 6. These photomicrographs show, and microscopic examination has confirmed the fact, that cold-rolled aluminium sheet recrystallizes but slowly on annealing. Microscopic examination of other gages gave results in conformity with what was expected, and in general recrystallization commences at lower temperatures and with shorter times with increasing deformation. This may be instanced by the summary of the microscopy of annealed sheets of various gages in Table XVI.

As to the mechanical softening of cold-rolled aluminium sheet from 15 to 4 scleroscope-number without concomitant recrystallization: In the present somewhat uncertain state of our knowledge, it appears that there may be a complete mechanical softening, which occurs and leaves the strained structure of the metal the same so far as the microscopic examination is able to show. With prolonged annealing, this may be followed by recrystallization and grain growth, while the softness remains the same or nearly so. The mechanical softening brought about by heating strained metal, such as cold-rolled aluminium sheet, is probably due to an undescribed change in the amorphous metal enclosing the remaining grain fragments resulting from extreme deformation in the cold, or to a continued absorption of the amorphous metal by these fragments, or possibly both. These changes in the condition of the amorphous metal are not sufficient to bring about visible changes in the etching characteristics of the internal structure.

Summary

The results of the tests made on the annealing of cold-rolled aluminium sheet show, and their practical application in the mill has proved, that there is no necessity for the present general practice of annealing aluminium. The effect of long-time annealings, such as are common in present practice, where sheets are exposed for say 24 hours at 375 deg. C., is to cause an undue coarsening and weakening of the metal which is evidenced by the coarse domes in the Erichsen test. In Table XIV, it will be noticed that all the samples gave very coarse domes. Fabricating blanks so annealed and which have undergone deep draws in the draw press also show the same coarse appearance at the edges of the drawn shapes, and this can be traced only to the long annealing period. The Erichsen apparatus in furnishing data as to the ductility of metal sheets, and their workability in the draw press provides a means of testing which is valuable.

Assistant Chemist in Forest Products (Male).—The United States Civil Service Commission announces an open competitive examination for assistant chemist in forest products, for men only. Vacancies in the Forest Service at Madison, Wis., at entrance salaries ranging from $1200 to $1800 a year, depending upon the qualifications of the appointee, and in positions requiring similar qualifications, will be filled from this examination, unless it is found in the interest of the service to fill any vacancy by reinstatement, transfer, or promotion.

The duties of appointees will consist of the investigation of such problems as the processes for the preservation of wood against decay, the wood distillation industry, and the practical problems of the pulp and paper industry.

Competitors will not be required to report for examination at any place, but will be rated on the following subjects, which will have the relative weights indicated, on a scale of 100: (1) physical ability, 10; (2) education and experience, 90.

The Forest Products Laboratory deals with economic and technical problems concerning the utilization of the products of the forests of the United States. The technical force of the laboratory consits chiefly of men who have had an engineering or a chemical training. The present staff consists of about 80 men receiving salaries ranging from $900 to $3500. Besides the laboratory at Madison, Wis., offices are maintained at Washington, D. C., San Francisco, Ca., and Portland, Ore.- A laboratory for testing the mechanical properties of timber is operated at Seattle, Was.

On account of the urgent needs of the service, applications will be received until further notice. Papers will be rated promptly and certification made as the needs of the service require.

Applicants should at once apply for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D.C.; the Secretary of the United States Civil Service Board, Customhouse, Boston, Mass., New York N. Y., New Orleans, La., Honolulu, Hawaii; Post Office, Philadelphia, Pa., Atlanta, Ga., Cincinnati, Ohio, Chicago, Ill., St. Paul, Minn., Seattle, Wash., San Francisco, Cal.; Old Custom house, St. Louise, Mo.; Administration Building, Baboa Heights, Canal Zone, or to the Chairman of the Porto Rican Civil Service Commission, San Juan, P. R. Applications should be properly executed, excluding the medical certificate, and filed with the Civil Service Commission, Washington, D. C., without delay.

The Use of Wood in Chemical Apparatus

Classified Results of an Inquiry by the Forest Products Laboratory, Regarding Practical Experience With Wooden Containers Used in Various Chemical and Metallurgical Industries

By A. W. SCHORGER

THE great expansion in the chemical and metallurgical industries during the past three years has resulted in increased interest in the use of wood for apparatus, particularly apparatus for use with acid solutions. In some cases manufacturers have constructed wooden apparatus because they could not obtain metal; but in many cases wood has a distinct advantage over all other materials when used in the presence of acids. The receipt by the Forest Products Laboratory of numerous inquiries about the suitability of various species of woods for use in such apparatus led to an attempt to collect such information as might be available on the subject.

Laboratory experiments, while possessing some value, were considered inadvisable since years would have been required to complete the tests; also it would have been impossible even to approximate certain commercial conditions. Accordingly, a large number of letters were sent out to various manufacturers and users of wooden apparatus asking what their experience had been, especially in regard to the use of wood with acid solutions. The numbered paragraphs of this paper embody a summary of the replies received. No responsibility is assumed for their accuracy.

It is interesting to note the geographical influence upon the replies, preference generally being given to a wood growing in the region in which it was used. In the North, Central and New England States white pine and Norway pine were used most; in the West, redwood, and Douglas fir; and in the remaining territory, longleaf pine and cypress.

Effect of Inorganic Acids on Wood

Wood is readily attacked by most of the inorganic acids. A 40 per cent solution of hydrochloric acid and concentrated sulphuric acid dissolves cellulose readily. More dilute acids attack the lignin and have slight action on the cellulose. In fact numerous attempts have been made to manufacture paper pulp by removing the incrusting materials with acids. For this purpose Barne and Blondel[1] used nitric acid; Orioli[2] using 40 per cent of a mixture of 20 per cent HNO_3 and 80 per cent HCl, obtained 50 per cent of long, strong fiber from 100 parts of wood; Lifschütz[3] employed a cold mixture of dilute nitric and sulphuric acids (3:1) and obtained 95 per cent of fiber. The solution was reused until the nitric acid was exhausted, leaving a solution containing H_2SO_4 and saturated with oxalic acid. Highly concentrated mixtures of nitric and sulphuric acid nitrate the wood.[4] Even very dilute solutions of hydrochloric acid or sulphuric acid contained in wood char it when it is dried at a temperature of 100 deg. C. The main action of acids on wood is hydrolytic. The lignin is separated from the cellulose fibers, the wood gradually disintegrating.

[1]Dingler's Polyt. J. 164 (1862) 464; 172 (1869) 238.
[2]Prakt. Handbuch der Papierfabr. 42 (1896) 163-32.
[3]German Patent 60, 233.
[4]Lifschütz, Ber. 24 (1891) 1186.

Pickling Tanks

1. A Chicago firm using hydrochloric acid and sulphuric acid at room temperature in its galvanizing department preferred Norway pine, but owing to inability to obtain suitable lengths was using yellow pine. The tank, using sulphuric acid of 15 to 16 deg. Bé and steam heated to a temperature of 82 to 99 deg. C., was made from longleaf yellow pine.

2. Wooden vats 15 to 40 feet in circumference are made of common pine, native of Massachusetts (probably white pine). This material requires less attention and shows a longer life than long leaf pine, cypress, or spruce. All of these woods have been thoroughly tried out. Absolutely dry cypress gave a slightly longer life than any of the others, but it was found commercially impractical to obtain thoroughly dry lumber. The sulphuric acid solution varies in strength from 3.5 to 8 per cent and the temperature ranges from 74 to 98 deg. C. The life of the tanks varies from one to two and one-half years, depending upon the size of the tank and the nature of the service, the smaller tanks lasting longest.

3. We use dilute sulphuric and hydrochloric acid at a temperature of about 65 deg. C. in our galvanizing plant. Both white pine and cypress have been used. The tanks fail by wearing off at the top and at the joints. The acid seems to eat away the material that holds the fibers together. Pine tanks last seven years and cypress from eight to nine. They are used only ten hours daily.

4. The hydrochloric acid is used undiluted and the sulphuric acid in about a 2 per cent solution, the former being generally used at a temperature of 21 deg. C. but has been used up to 65 deg. C.; the sulphuric acid is used at 65 deg. C. The tanks for these acids have been made of cypress, white pine, fir or oak, chiefly the first two; and it is our experience that as far as the wood is concerned its chief asset was in its natural advantages as a tank lumber, i. e., for holding water or any liquid, and in its ability to stand hard usage, as thousands of tons of steel are passed through the tanks in the shape of angles, etc. In being lowered and raised in and out of the tanks the steel causes considerable chafing and wear. Tanks which have now been in use six years show no appreciable change in the strength of the fibers $\frac{1}{16}$ to $\frac{1}{8}$-in. beneath the surface and resist the insertion of a knife blade the same as new wood. The breaking away of a splinter from the planks appears to be almost as difficult as with new wood.

5. For ordinary tanks for pickling steel products we always use cypress, which we understand from users of our tanks is very durable so long as the contents are not stronger than a 5 per cent solution.

6. We use hydrochloric and sulphuric acids at a temperature of 70 to 80 deg. C. We have had best success with cypress wood. The life of the tanks in our galvanizing department is about two years. The acid makes the wood spongy, and in about two years' time the solution begins to ooze through the staves so badly that the tank must be abandoned. The wear and tear upon our tanks is rather severe from the fact that we are galvanizing heavy parts and heavy bundles of small parts.

7. We use cypress with the best results for galvanizing tanks.

Storage Tanks for Hydrochloric Acid

1. The hydrochloric acid is stored in a double-walled tank, the inner being made from "Louisiana red gulf *cypress*" and the outer tank of "special heart grade" *longleaf yellow pine*. The space between the tanks is filled with highly refined pitch-tar, which remains in a plastic condition. The inside tanks are sometimes painted with two or three coats of a mixture of rosin and pitch, and before assembling each stave is dipped in a hot tar solution.

2. Our experience—that is to say, the reports of our customers—has been that the best material for muriatic acid is either *longleaf pine* or Washington *fir*.

3. In the manufacture of muriatic acid, storage tanks were made of California *redwood*, and the acid was also shipped in tank cars made of the same wood.

The wood was prepared by first boiling tar until all the volatile products at the boiling point of the tar were distilled off, and then the clear redwood was immersed in this and boiled for about half an hour. The staves were then used to make up the tanks. The muriatic acid was maintained at atmospheric temperature and no heating was carried on in the tanks. To the writer's knowledge tanks made up in this manner lasted twenty years.

4. You can make wooden tanks and coat them with a mixture of asphaltum and some wood tar and they will stand quite a long time. We have some wooden tanks so built that we have been using for quite a number of years for transporting and storing muriatic acid. However, there is no wood that we know of that will stand for any length of time, either treated or not, the effects of either nitric or sulphuric acids.

5. We are manufacturers of sulphuric, muriatic, and hydrofluoric acids; the most serious trouble encountered is that of concentrating our acids to the commercial specific gravity. The fumes from the latter acids are weak, warm and penetrating. The best grade of wood which we have found to answer our purpose is white pine. We have also used some cypress with fairly good success; nevertheless we consider white pine the best for our purpose and for all the acids produced at this plant at various temperatures and gravities.

6. Hydrochloric acid scarcely attacks wood, especially if the latter is soaked in paraffin wax.

Apparatus for Use with Acetic Acid

1. We use a great many wooden tanks in connection with our acetic acid operations. We have used redwood, cedar, and cypress tanks. The cypress are the most satisfactory. We also use wooden pipe lines, and all of these are made from spruce. They are only fairly satisfactory, however.

2. Wooden tanks are used in the manufacture of the vinegar and in its transportation. In both cases fir and cypress are used and with careful treatment they last a great many years. The acid seems to preserve the wood.

3. Acetic acid and vinegar are usually handled in fir tanks.

4. The writer has had experience in the use of wood in the manufacture of acetic acid. Ordinary white pine tanks were used to store the various strengths of acetic acid. Acetic acid was also shipped in second-hand whiskey barrels and we noticed no effect of the acid on the wood.

We also performed concentration and purification of acetic acid in a wooden tower made of clear *white pine*. This tower showed no effects of the acid.

5. We use wooden tanks made of cypress and pine in the manufacture of vinegar, the acetic acid content of which never exceeds 11 per cent.

6. Douglas fir is used almost exclusively by vinegar plants.

7. During the past few years we have had occasion to make smoke condensers for a certain company. The material must resist the action of acetic acid. After a good many years of experience they have settled on Norway pine as the proper material. They have tried Western fir and condemn it absolutely.

8. We have used wooden tanks as containers for pyroligneous acid, and with good results. These tanks are made of pine, and we have some still in good condition that have been in constant use for the last fifteen years.

9. A great many cypress tanks are used in the generation of vinegar and acetic acid and for holding vinegar.

Separators for Storage Batteries

Wood is used extensively for separators in lead storage batteries containing sulphuric acid of from 1.2 to 1.4 specific gravity.

The wood must be given a preliminary treatment; for when it is used in the natural state substances very injurious to the lead plates are formed in presence of the sulphuric acid. Acetic acid is generally considered to be one of the most undesirable substances produced, but according to Skinner[2] a small quantity of acetic acid is beneficial rather than harmful to the negative plates. He finds that "white pine, Douglas fir, and the common species of cedar" are especially desirable for separators. In Skinner's patent, the woods, before use, are steamed under pressure for about 12 hours or boiled at atmospheric pressure for from 21 to 48 hours. The swelling and softening thus produced lower the internal resistance of the separators. In previous patents the separators were first treated with a 25 per cent solution of sodium bisulphite[3] at a temperature of 100 to 175 deg. C.; or with a 15 per cent solution of sodium sulphite[4] at 100 deg. C. for one hour. These solutions remove a portion of the lignin, and their use is founded on well-known methods of manufacturing paper pulp.

Morrison[5] treats the separators with melted paraffin. Heap[6] employs an alcoholic solution of caustic potash,

[1] U. S. Patent 1,130,640 (1915)
[2] Skinner, U. S. Patent 1,[illegible] (1914)
[3] Skinner, U. S. Patent 1,[illegible] (1914)
[4] U. S. Patent 1,068,77[illegible] (1913)
[5] U. S. Patent 1,051,5[illegible] (1913)

in which the separators are treated for four hours at 140 deg. C. and at a pressure of 100 pounds. Marino[10] steams the separators for 15 minutes at 120 deg. C. and then subjects them to oxidation by immersion in a 20 per cent solution of hydrogen peroxide for about 3 hours. The separators are finally steamed again for ten minutes at a temperature of about 110 deg. C. The method of Dodge[11] for preparing the separators for use consists in soaking them successively in dilute sulphuric acid and caustic potash. Whitehead and Marino[12] first submit the wood to an ammoniacal copper solution and then to a bath of ammonia sp. gr. 0.88. The separators are then treated successively with water, nitric acid, and sulphurous acid, and finally with alcohol, caustic potash, and ethyl acetate in various proportions.

Among the woods considered as having special value for storage batteries are yellow pine[13], cypress *(Taxodium distichum)*, and redwood *(Sequoia sempervirens)*[14]. Cypress is also considered to be least affected by alkaline solutions.[14]

Lyndon[15] states that for large size station storage batteries heavy wooden tanks lined with lead are universally used. These should be made of sound oak, pine, or teakwood thoroughly dried and boiled in paraffin or its equivalent, so that the pores may be completely filled. "Resinous wood such as pine has proved to be the most satisfactory and durable." This author also states that basswood is invariably used for the separators. At the present time basswood is being used to only a limited extent, preference being given to cypress, redwood, Douglas fir, and Port Orford cedar.

Tanks for Saponification of Fats

1. Several of our customers using our tanks in the process of recovering glycerine from soap fats specify 4-inch genuine Louisiana red cypress for the bottoms and staves, and extra heavy hooping. This, we understand, is not only due to certain acids used in this process, but also because the fat contents of the tank are boiled.

2. Our experience is practically limited to the use of wooden tanks in contact with a solution of sulphuric acid containing also sulphonic acids, at a concentration of 1 to 2 per cent for each component at a boiling temperature, in the operation of the Twitchell process for fat splitting. We use for this purpose Louisiana cypress.

Tanks in continuous use with the Twitchell process, if properly constructed, have a life of at least ten years. The inner layer becomes charred in appearance and we therefore use staves not less than three inches thick; the charring will not penetrate more than about ¾-inch. We have recently taken down a tank which has been used about fifteen years and find the inside of the staves charred as described above, while the remainder of the wood still remains in serviceable condition. (A portion of a stave sent to this laboratory proved to be dense, resinous longleaf pine.)

[10]U. S. Patent 1,023,948 (1912)
[11]U. S. Patent 1,000,330 (1911)
[12]English Patent 20,143 (1905)
[13]Waldron, U. S. Patent, 463,879 (1891)
[14]Taylor, U. S. Patent, 1,012,751 (1911)
[14]Edison, U. S. Patent 754,858 (1904)
[15]"Storage Battery Engineering" (1911)

Miscellaneous

1. The slight experience that we have had leads us to believe that cypress wood stands the action of all kinds of acids the best.

2. We have had so many complain of Washington fir that we have given up the manufacture of Washington fir tanks for acid of any kind unless specifically ordered. We consider yellow pine in general better than white pine.

3. We make the tanks principally from Louisiana red gulf cypress. In some cases longleaf pine is requested. We have also made some from Oregon fir. It appears that for certain chemicals longleaf pellow pine is specified by the users on account of the acid resisting qualifies of the pitch contained in the pine.

4. Longleaf pine seems to be most popular with the paper mills for sulphite solution, while cypress is universally demanded by the chemical companies.

5. We have tanks constantly in use exposed to dilute acetic, muriatic, sulphuric and chromic acids, and, in our opinion, nitric acid could also be used if sufficiently dilute. These acids are in various dilute solutions, say about 5 to 10 per cent, and above the solution they exist in the form of steam. The temperature rises as high as 100 deg. C.

The best wood to use for these tanks is longleaf yellow pine as it seems to last longer than any other kind. Many of the dye-stuff and chemical manufacturers use wooden tanks generally, and a good many use acids in them. In time the acid softens the wood and causes the tanks to leak no matter how often they are tightened up. Some of our tanks have lasted as long as four years and given good service.

6. We have recently made some acid towers for one of the paper companies and they find Western fir satisfactory. This material comes in contact with sulphurous acid principally.

7. Wood filter-presses are almost invariably used for filtering acid mixtures. Considerable difference of opinion exists as to what woods are best suited for the filtering of various acids. We usually use paraffined hard maple. The plates are sometimes made of longleaf pine, oak, ash, and cypress.

8. We use an acid solution in our plant which is almost saturated with sodium sulphate and chloride. The acids present are sulphuric, sulphurous, and hydrochloric, the maximum strength being about 1 per cent. The temperature of the solution is about 30 deg. C., although in the leaching tanks 100 deg. is approached at times. We are using both Douglas fir and redwood. After three years of service both kinds of wood appear in good condition.

We also handle our waster smoke after passing through a scrubbing tower, through an exhaust fan built of wood. Under these smoke conditions the Douglas fir loses its strength and become black and soft. When there are no particular strains to resist, it lasts for several years. We are trying out redwood for this purpose and expect better results.

9. Fir will withstand the action of 18 per cent hydrochloric acid for about six months; North Carolina yellow pine will withstand the action of weak sulphuric acid up to about 5 per cent for one year, but even before that time, in case the acid is agitated, the wood begins to shred.

10. Most of our experience has been in handling hydrofluosilicic acid (H_2SiF_6) mostly at strengths of 10 per cent and 35 per cent The former solution is always handled at 100 deg. F. and the latter at atmospheric temperature. This acid has been used in wooden tanks made of fir, yellow pine, and cypress. We have also packed the 35 per cent acid in oak barrels. The wooden tanks are always lined with asphalt and the barrels with paraffin. None of these woods will stand the acid for any length of time unless the wood is coated with some lining. Whenever the acid is in contact with wood the alternate fibers are dissolved away, leaving the wood in a condition very much resembling a pad of paper.

Pipe made of tamarack was used for carrying 12 per cent hydrofluosilicic acid at a temperature of 100 deg. F. After three years' service it was still in good condition.

11. One of our lines conveys a solution containing 4 per cent or 5 per cent sulphuric acid. The pipe (tamarack) seems to remain as sound as ever.

12. While cypress gives better results for hot acids, yellow pine is superior to it for cold or warm acids.

13. Cypress tanks are used almost exclusively for acids and chemicals, and for hot liquids, as nothing else will give as lasting service.

14. Tamarack is a very satisfactory wood for silos, as it resists decay and the effects of the acids formed by the silage.

15. The pipe is made of white pine, selected free of all sap and other imperfections. We have furnished it extensively to acid factories, chemical works, vinegar and cider plants, for conveying vinegar, cider, and various acid liquors, such as dilute sulphuric, nitric, muriatic, and acetic acids.

16. Pipes made of white pine and tamarack are used for handling mine waters and dilute acids.

17. The lining of flues and hoods over acid vats (HCl and H_2SO_4) appears to last longer when made of spruce than of native pine (Massachusetts). This is probably due to the fact that the spruce is harder than the pine and does not disintegrate so rapidly around the nails.

18. We use cold HCl 3 deg. Bé, and boiling hot H_2SO_4 2 deg. Bé, and prefer old growth Oregon fir (Douglas fir).

Boehringer and Sons[16] use chlorinated compounds for coating and impregnating wood. It is claimed that substances possessing to a high degree chemical inertness towards acids, halogens, etc., are obtained when animal and vegetable oils, fats, and waxes, are chlorinated under such conditions as will insure the introduction of at least 30 per cent chlorine. Chlorinated products from mineral oils show a high degree of resistance towards the action of alkalis and acids.

Forest Products Laboratory, Forest Service,
United States Department of Agriculture

American Iron and Steel Institute

The fourteenth general meeting of the American Iron and Steel Institute will be held at the Waldorf-Astoria, New York, Friday and Saturday, May 24 and 25. A business meeting for the election of seven directors to serve for the next three years was held Monday, May 6, at the office of the Institute, 61 Broadway.

[16]French Patent 433,415 (1911)

Defects in Industrial Rubber Goods

A Glossary of Defects with Suggestions as to Cause and Prevention

By Frederic Dannerth

OCCASIONAL claims for damages because of defects in finished products is an experience common to most manufacturing industries. This is obviously due to the fact that no product is perfect in the literal sense of the word. Hence *perfection* is only a relative conception, and the various tests applied to finished products are nothing more than methods used for determining how near perfect, the product is.

Defects may be due to the raw materials, to the processes of manufacture, or to the conditions under which the finished goods were shipped and stored. The fact that the goods were defective when they came into the possession of the consumer, is usually the form in which the complaint reaches the sales manager. So far as the writer is aware no attempt has been made to record concisely any of these defects in rubber goods, and it would seem that such an enumeration is especially desirable at a time when buyer and seller are making an honest attempt at understanding each other. A defect may be defined as "a property which impairs the value of the product, and renders it less fit for the purpose for which it was intended." If a perfect product be called *normal* the defective product may well be called *abnormal*, just as the physician applies these terms to persons who are sick or deformed. Following the analogy, it is possible to determine the cause, characteristics and remedy for each defect, and discover means for preventing its occurence.

Tackiness

This designation is given to the soft, sticky character possessed by low-grade, crude rubbers. In the case of raw Guayule this is due to the presence of resin to the extent of about 20 per cent, and the effect may be corrected to a considerable degree by simple deresination. In other cases the sheets of rubber are seen to melt and become semi-liquid when placed in the vacuum dryer; or, if exposed in a drying loft the sheets drop off the poles. This may be due to (1) depolymerization, (2) oxidation, by air and sunlight. It is probably not due to bacterial action or to the presence of carbohydrates.

Decay

It has been noted that crude rubber will *perish* or decay if exposed to oxidizing influences. In the case of low-grade rubbers the development of an acid smell is noticed, the rubber first softens and later becomes hard and brittle. This defect is induced by the action of heat and light. It should however be noted that rubbers rich in resins are not always the most liable to oxidation.

Loose-Sleeve Effect

This condition is noticed in the case of rubber-covered rolls. When the roll is put into service as part of a machine in the textile or the leather industry, the rubber compound works loose from the metal core of the roll. This may be due to careless vulcanization, or to the unsuitable character of the compound used for the "base," the part directly adjoining the metal. Aside

from this it may be due to the fact that the metal roll was not wiped free from grease, or the naphtha used for wiping the roll may have contained too high a percentage of non-volatile oil. In the latter case a film of oil remains on the metal core and the rubber compound fails to adhere to the metal. The defect may be avoided by eliminating the causes.

Defective Friction

This is noticed as poor cohesion between the plies of coated duck in the case of belting, hose, auto tires and the like. It may be due to (1) the moisture in the cotton duck, (2) the unsuitable character of the friction compound, or (3) to improper method of vulcanization. The defect is especially objectionable in the case of auto tires. Here the numerous pulling forces on the layers of cotton duck make severe demands on the friction compound. To avoid defective friction the indication is therefore to use a compound containing a sufficient quantity of good rubber and to dry the cotton fabric before it is coated.

Dry Friction

This is sometimes designated as "dead friction." It is due to the fact that not enough tacky binder has been used in the friction compound, or it may be due to over-vulcanization.

Boot Leg

This phrase is applied to belting, where the middle plies of cotton duck have become separated during use on the pulleys. It may be caused by dry friction, or defective friction or by the incorrect manner in which the belt was run on the pulleys. The edges of the belt remain connected, so that the belt appears as a hollow body open at each end.

Under-Vulcanization

Compounds which have been under-vulcanized, or under-cured, as it is called in the factory, are recognized as soft and flabby with negligible tensile strength and no marked elasticity. When such articles are stretched they do not come back to their original form readily. An expert would say that their "permanent set" or *permanent elongation* is high. Under-vulcanization may be due to (1) the use of an insufficient amount of sulphur, (2) the use of an insufficient amount of accelerator, (3) the short duration of the vulcanizing process, or (4) to the temperature at which the compound was vulcanized.

Over-Vulcanization

If a compound appears hard and stiff when removed from the vulcanizing chamber, this may be due to over-vulcanization (over cure). In this case the product would show good tensile strength, but it could not be stretched very far without rupture. Over-vulcanization should be carefully avoided, as it cannot be corrected, whereas in the case of under-vulcanized products, where the defect is due to too short a cure or to too low a temperature, this may be helped by subjecting the product to further vulcanization. The defect may also be caused by the use of excessive amounts of vulcanizer or vulcanization accelerator. It is especially undesirable in such articles as steam hose for railroads, steam packing, power-transmission belting and auto tire treads. As these products are subjected to high temperatures after they are put into use they should rather be slightly under-cured in the factory.

After-Vulcanization

This is seen in articles which contain an unusually large amount of free sulphur, or products which are subjected to high temperature while in use. The remedy or rather the preventive is to use less sulphur and less accelerator. At the same time the vulcanization should be effected rather by a long cure at a comparatively low temperature.

Slow-Vulcanizing Compounds

This defect is noticed in those compounds which contain a large percentage of retardants. These agents have a preferential affinity for the sulphur so that the rubber does not have an opportunity of combining with its allotted portion. If it is necessary to use retardants in order to produce a given effect in the finished product, care should be taken to incorporate in the recipe an accelerator as a corrective.

Dry Mixings

This is observed on the mixing mill during the mixing of compounds containing a large proportion of such dry fillers as whiting, infusorial earth, magnesia, asbestos and the like. In some cases a compound may mix easily on the mixing mill, but when fed into a tubing machine, the tube which is extruded (squirted or forced) through the die will have a tendency to crumble. In compounds which show these signs it is fair to assume that the absence of soft fillers has prevented the necessary cohesion and adhesion among the particles. It may be caused by the use of excessive amounts of dry mineral fillers or of reclaimed rubber. Reclaimed rubber stock containing as much as 50 per cent mineral matter, with 50 per cent rubber and organic matter is sometimes found to be very "dry" when run on the mixing rolls. The defect of dry mixings may be corrected by adding to the recipe such lubricators as black oil substitute, white oil substitute, petrolatum, unoxidizable vegetable oils, paraffin wax and pontianak.

Micro-Porosity

This defect is observed as small holes the size of a pin prick, which appear all through the finished product. It may be caused by the presence of air or moisture in the rubber dough previous to vulcanization. It may be corrected by the addition of paraffin wax, vegetable waxes, or asphaltum products to the recipe. If due to moisture, the mineral powders must be dried carefully before being used for compounding. The defect of micro-porosity is especially objectionable in articles which are to be used under pressure: air-brake hose; signal hose; vacuum hose.

Discoloration

This is observed as a grayish cast on products which were expected to come out a pure white or a bright red. For example, in cases where a high-grade white product is desired, zinc oxide is the preferred mineral filler. But if the zinc oxide contains lead compounds, an

impure white or even a gray product will be obtained, depending upon the actual amount of lead present in the mineral powder. As another example we have the case of crimson antimony sulphide, commonly used wherever a bright red-colored product is desired. If the antimony sulphide contains lead compounds, the resulting product will have a cloudy red color. The defect can be readily prevented by testing the zinc oxide and the antimony sulphide for the presence of lead before it is used.

Blooming

Of all defects observed in rubber goods, this is no doubt the most common. It refers to the separation of sulphur on the surface of the goods, and is still regarded by some buyers as a "good sign" of a well-made product. Salesmen frequently find it impossible to sell hose to some consumers unless the outside is liberally coated with sulphur crystals. This coating of fine sulphur is caused by a wandering of the excess sulphur to the surface. This is the free or uncombined sulphur. The bloom may be avoided by reducing the amount of sulphur in the receipe, or by using catalytic agents, or by reducing the amount of organic retardants in the recipe. If it is desired to remove the deposit from the finished rubber goods, this may be done by boiling the finished article in a weak solution of caustic soda. This operation is frequently carried out with rubber stoppers, which are to be used for chemical laboratory work. Bloom is especially objectionable in the case of articles used for food or medicinal purposes.

Blistering

If moisture is contained in the powdered mineral fillers, or in the raw rubber, this will produce the effect known as blistering when the compound is vulcanized. In extreme cases pronounced sponginess results. The defect in the majority of cases may be avoided easily by eliminating the cause. If the compound contains any substances which are volatile at the temperature of vulcanization, these will produce a similar effect. The plan then should be to avoid in rubber mixings any substances which might *volatilize* at a temperature of 300 deg. Fahr.

Ageing

This term is commonly applied to the drying-out or hardening of rubber products which are exposed to certain conditions. In the simplest case it is due to the recipe used, and for that reason the compounding man should be well aware of the conditions under which the compound is to be used, that is, the *specific* conditions. The ageing or surface hardening may be traced to any one of several fillers used in the compound, to the factors of time and temperature during vulcanization, or to the influences of temperature, light and air to which the finished product is exposed when in service. It has been difficult to devise a *laboratory* test which would take the place of the *service* test for this defect. And this fact in itself shows how difficult a problem it constitutes. One thing has been definitely established: the use of certain hydrocarbons in proper proportions will insure longer life for the product. These hydrocarbons include pitch products obtained from petroleum, coal tar and gilsonite, either alone or mixed. The decomposition, decay or death of a vulcanized rubber compound is influenced to a very considerable degree by the temperature to which it is exposed when in service. For that reason the life test usually applied in the laboratory to predetermine the liability of goods to decay consists in exposing the sample to definite higher temperatures for a definite time.

Swelling

This defect is found in packings used in connection with tanks where animal or vegetable extracts or fats are stored. Such substances as tanning extracts and beer extracts have a definite swelling action on some packings, and this is undesirable. Then again a hose used for conveying gasoline should not swell to any appreciable extent. This non-swelling property is secured by a careful choice of compounding materials, for it is a matter of common knowledge that rubber itself will swell appreciably when placed in gasoline (petroleum naphtha).

Permanent Elongation

This is observed in products which have been under-vulcanized, or which contain a very small percentage of new rubber, a large percentage of reclaimed rubber, or such gums as pontianak. Washed and dried pontianak contains possibly 25 per cent of actual rubber substance so that a compound made entirely of this will show little or no "come-back." In other words, the *permanent set* will be considerable. For example, if a test specimen be vulcanized and scribed with marks 1 in. apart, and the specimen then pulled apart in a testing machine, it will be noticed that the specimen will stretch to a considerable distance without rupturing, but when the pull is released the specimen will not return to its original position. The permanent elongation is excessive. For that reason pontianak gum exclusively is not used for the manufacture of commercial products. It may be stated as a general rule that the less permanent elongation which a product exhibits, the more valuable is the product. For this reason it has become common practice when drafting specifications to place a limit on the "permanent elongation."

Stretch

The ability to stretch and then come back and resume approximately its former position is a characteristic property of a well vulcanized, good rubber compound. Hard-rubber compounds are obviously excluded from consideration at this point, although they do show the physical property of *elasticity*. The percentage of stretch possessed by a rubber compound bears a certain relation to the amount of rubber which it contains. Hence it has become customary to carefully determine this property when the relative value of rubber products is to be ascertained. A finished rubber compound which will show little or no stretch is obviously defective, provided that the compound is intended for use where elasticity is an important factor. For it is quite possible to imagine cases where the compound would be used merely as an insulating layer, where the question of stretch would be relatively unimportant.

Tensile Strength

This is a property exhibited in varying degree by vulcanized rubber compounds, and it may well be considered a measure of the quality of the product. If

the strength is defective, this may be due to the use of an insufficient amount of sulphur, accelerator, or rubber; or the compound may be under-vulcanized or over-vulcanized. It may well be said that this property is one important indicator of successful manufacture. The interdependence of tensile strength and stretch must be recognized and taken into account at all times. If one is increased the other will be diminished, and the reverse is likewise true. The object then would seem to be this: To discover the one point in the vulcanizing process where the required amount of tensile strength is secured, and a maximum amount of stretch is obtained. For example, it is possible to specify that a rubber compound is desired which possesses a tensile strength of at least 300 lb. per square inch, and the stretch shall be not less than 1 in. to 7 in. If then a series of compounds all show a stretch of 1 in. to 7 in., that one will be the best which possesses the greatest tensile strength. For example, three different varieties of good rubber when vulcanized under the same conditions show tensile strength tests of 2830 lb., 3055 lb. and 3170 lb. It must, however, be added that this test does not indicate whether the life of the compounds is in the same ratio as the tensile strength figures.

The Rubber Trade Laboratory,
Newark, New Jersey.

Manufacture of Nitric Acid

AT A MEETING of the Delaware Section of the American Chemical Society at Wilmington on March 8, Dr. Edward Hart of Easton, Pa., delivered an address on nitric acid. Dr. Hart is one of the pioneers in the distillation of nitric acid and the inventor of the Hart condenser. He said it had been his lot at various times to be called into consultation by men of affairs, heads of manufacturing industries, in such a way that he could gage with a fair degree of accuracy the methods they were pursuing. He said he had never come in contact with men organized on better lines or pursuing methods better calculated to bring success than those of the chemical organization which overshadows Wilmington.

One little seed which he planted there many years ago has grown under its fostering care, he said, and has developed until the old boy who planted it can scarcely recognize his child.

There has developed, too, one of the humors of the situation, for what has come to him of the methods of operating, has come through roundabout channels, and he had never seen his nitric acid plant running in Wilmington.

About the year 1893, in response to a request from the du Pont de Nemours Company, he visited Wilmington, aw Mr. Jackson, and sold him six condensers. Shortly after he turned the propaganda work over to others and devoted himself to purifying nitric and hydrochloric acids for which he invented automatic apparatus, still industriously at work.

Out of those six condensers with ½-in. tubes have been developed the present batteries which for several years have been turning out the sea of nitric acid that is so potent an instrument in our chemical transformation as a nation.

In taking up the history of nitric acid, Dr. Hart referred to the preparation by the latin Beber (Nuremberg edition, 1545), which seems to have been the first. Georg Agricola described its preparation in the first edition of De Re Metallica (Hoover's Trans.). Lazarus Erckers described the preparation of aqua fortis in 1574 in The Beschreibung aller Fueremsten mineralischen Ertzt und Bewercksarter (also in edition of 1580). Glauber, after whom Glauber's salt is named, was the first to prepare hydrochloric acid from salt and sulphuric acid. He also prepared nitric acid from saltpeter and sulphuric acid, although he did not directly describe either process. Caspar Neumann also described the preparation of nitric acid from niter and sulphuric acid (Trans. by Wm. Lewis in 1759). In 1848 Dumas also described its preparation in Traite de chimie applique aux arts, Tome 7, p. 283.

About 1890 Dr. Hart began to make nitric acid. At that time the firm of Baker & Adamson, in Easton, Pa., of which he was a member, had been buying nitric acid and refining and selling the chemically pure article. The acid came to them on flat cars in carboys

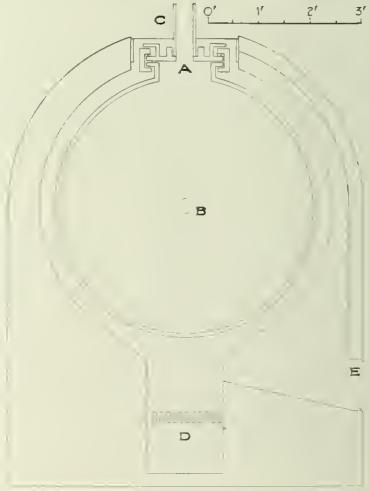


FIG. 1

Hart's Nitric Acid Retort.

and they had so much trouble from breakage and so many of the men were burned that they decided to make their own acid from nitrate of soda and oil of vitriol, 66 deg.

Being dissatisfied with the retort figured in the books, Dr. Hart devised one very much like that shown in Figure 1, 4 ft. diameter and 4 ft. long. It had about eight ½-in. holes bored in the top plate, and after the charge was made eight Liebig glass condensers were fastened in the holes, four on each side of the furnace. Then the fire was started and the trouble began. A 2-gal. bottle was placed under each condenser and soon

yellowish-red fumes of nitrosyl chlorid were pouring from each bottle and forming a pool in the room. It was evident that the condenser system would not do, but it was not until some time later that the first Hart condenser was devised, erected, and patented. At first they had a great deal of trouble with boiling over until it was discovered that the two boys running the apparatus were systematically forcing the fire so as to make it boil over to get short hours. After replacing them this trouble disappeared.

Dr. Hart's first publication on the subject was in the *Journal of Analytical and Applied Chemistry*, of which he was the editor (Vol. 5, 1891, p. 382). Two papers were then published simultaneously in the *Journal of the American Chemical Society* which he then edited (Vol. 17, 1895, pp. 576, 580). In these papers he dealt with condensation generally and described the condenser as patented. It had fifteen 1-in. tubes 6 ft. long and condensed 785 lb. acid from 1000 lb. niter and 1000 lb. oil of vitriol, 66 deg., in six hours actual running time with 150 lb. pea anthracite coal.

According to the census of 1900 the production of nitric acid in the United States was about 15,500 short tons, most of which was used in the manufacture of nitroglycerine and guncotton. This has, of course, vastly increased and, since the great war began, by leaps and bounds. Dr. Hart pointed out that until nearly 1900 there were only a few large producers. Most installations were of only one or two retorts, and little effort was made to save the bleeder gases (mostly NO_2). The conversion of this gas into HNO_3 is a difficult operation, for it involves absorption in water and oxidation with atmospheric oxygen. Since the latter is mixed with four times as much nitrogen and is only slightly soluble in water, large surface is required and high yield can hardly be expected. This part of the subject is best studied in connection with synthetic nitric acid. He called attention to the Guttmann process in which thin earthenware tubes are used for condensation and the Valentiner process in which distillation takes place in a vacuum. He has already detailed these methods in the article on nitric acid which he wrote for Sir Edward Thorpe's Dictionary of Applied Chemistry. The latest method is that of Hough, who uses a duriron condenser. Most of the acid from Chile saltpeter is being produced in some modification of the Hart condenser. The latest form of this apparatus for large installations is shown in Figure 2. In the early condensers asbestos was used as a lute between tube and manifold. This has been displaced by putty. Dr. Hart did not know who invented this putty, nor who devised the pulsometer and dash pot operated with compressed air used for the condensing towers.

There is one property of nitric acid which demands special attention. Under certain conditions it is a strong oxidizing agent and since one set of products of the operation is nitrogen oxides which may be regenerated it is entirely possible that this will repay further study.

If cotton is treated with strong nitric acid, we get nitric esters. The oxidizing action is negligible Since cotton may be considered an alcohol, we should expect the same result from other alcohols. With ordinary ethyl alcohol we do in fact get ethyl nitrate, but this manufacture should not be attempted on a large scale the first time. If all oxides of nitrogen dissolved in the nitric acid are destroyed by adding a little urea the reaction then goes smoothly and we get pure ethyl nitrate. Without the urea we might go out the door by way of the window. When aromatic compounds like benzene are treated we get a different class of substances: the nitro compounds, in this case oil of myrbane. The oxidizing effect which is of the third class is most pronounced when the nitric acid is diluted. For example: strong nitric acid and phenol give the nitrophenols. But dilute nitric acid boiled with phenol gives beautiful yellow crystals which on examination are found to consist almost entirely of oxalic acid.

Dr. Hart said if he ever gets the time he wants to see whether it is possible to make oxalic acid in quan-

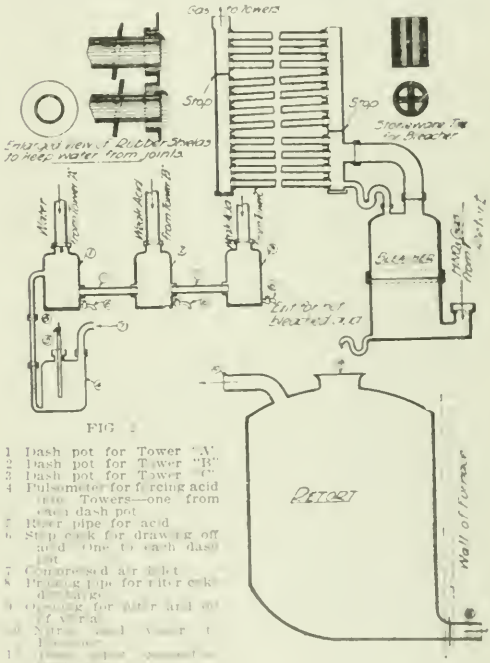


FIG. 2

1 Dash pot for Tower "A"
2 Dash pot for Tower "B"
3 Dash pot for Tower "C"
4 Pulsometer for forcing acid into Towers—one from each dash pot
5 Riser pipe for acid
6 Stop cock for drawing off acid—one to each dash pot
7 Compressed air inlet
8 Pressure pipe for filling cock and discharge
9 Opening for filling and cleaning
10 Nitric acid vapor from retort
11 Sulphuric acid vapor from retort

tity from cheap organic material, like sawdust for example, by boiling with dilute acid and regenerating the oxides. To all intents and purposes, working in this way we would get our oxidation at the expense of atmospheric oxygen. This would be an especially attractive idea where waste power is available, for example where power is used for operating trolley lines where the peak comes at 6 a. m., 12 m. and 6 p. m., with practically no load from 12 p. m. to 5 p. m. During the five-hour interval of no-load the power would be at work generating oxides of nitrogen to compensate for unavoidable losses.

He said he was satisfied that fields like this will yield a rich reward to the successful cultivator, and that as the years go by nitric acid, ammonia, and the other nitrogen derivatives will play a larger part in our future.

In this connection an interesting article by W. Ed

Burkhard has just appeared in the March number of the *General Chemical Bulletin* which will supplement very well the data given by Dr. Hart. Mr. Burkhard says that without this acid we should not have all our beautiful variegated artificial colors and dyes but would be limited to the comparatively few serviceable natural dyes; we should also be without some of our finest lacquers, artificial silk, collodion, celluloid, nitroglycerine, dynamite, T.N.T. and so on for an almost unending list of extremely valuable materials. He says that until very recently all the commercial nitric acid in the world was made from saltpeter brought from Chile.

The refined nitrate as used in acid manufacture has from 92 to 98 per cent $NaNO_3$, generally 95 to 96 per cent. For this purpose it should not contain over 1½ per cent NaCl as in the distillation the muriatic acid formed destroys an equivalent amount of nitric acid.

The commercial manufacture of this acid started in this country in 1824. However, this industry did not assume any importance until the discovery of nitroglycerine in 1862, since which time the money investment and labor used have steadily increased until in 1915 the United States produced nearly 80,000 tons of nitric acid at fifty-two works and 112,000 tons of mixed acid at thirty-seven works. The world demand for nitrogen compounds has risen to 750,000 tons a year.

There are three general methods for manufacture of nitric acid now in successful use—the continuous, the vacuum, and the atmospheric pressure. The last is the one in most general use.

In the continuous process, which was successfully used in England, the nitrate is mixed with an excess of H_2SO_4 in a separate vessel where solution is effected and chlorine and nitric oxides are given off. This mixture flows continuously into a still which is heated, effecting distillation of all the nitric. The residue in the still is drawn off at frequent intervals. They claim the distillate to run 94 per cent nitric acid of a fine quality and a "soup" of 30 per cent H_2SO_4. However, in spite of all the good qualities claimed and seemingly theoretical advantages, the process does not seem to have found favor in America. The "nitre soup" is the residue in the still after the nitric is distilled off. It consists of sodium sulphate with from 20 to 30 per cent free H_2SO_4, very often approximating an acid sulphate, *i.e.*, $NaHSO_4$.

The vacuum or Valentiner process is successfully used in this country to some extent. This process is identical with the common atmospheric process except that it is operated under a vacuum which, of course, means a lower distilling temperature. However, in order to expel the last trace of nitric acid the final temperature is nearly the same in both cases, approximately 175 per cent—250 per cent C. In the vacuum process all leaks suck in air, thus rendering more difficult the complete condensation of the acid, but the plant is remarkably free from fumes, which is an important factor. Also, a gang of repair men must be constantly on the alert, for leaks do not show themselves as in the common process.

The soda and acid, generally 66 deg. Bé. H_2SO_4, though stronger acid is sometimes used, are charged into an iron still. The size and design differ widely. The sulphuric acid is usually calculated so that the "soup" will be as fluid as possible at as low a temperature as practical to prevent excessive corrosion. The normal acid sulphate fulfils these conditions. The heat is applied gently to the stills to prevent boiling over and the gases are condensed. By fractionating the condensate, acids of various strengths and purity are recovered. The impure acid is purified from its volatile impurities such as iodine, chlorine and nitrous acid (which gives it color) by bleaching, which is simply boiling and drawing off the impure vapors.

The process for the future is the synthetic, which promises to put the soda or decomposition process in the second place. The raw materials, air and water, are to be had for the taking. Since the war started Germany has been denied all imports of soda and so would have been quickly forced to the wall for lack of explosives had her chemists not risen to the occasion and made practical the industrial synthesis of this acid.

Most nitric acid is used for nitrating, that is, introduring the NO_2 group into organic compounds. As this action produces water, the acid is quickly diluted and loses its power. To overcome this mixed acid is used. This is a mixture of either ordinary or fuming sulphuric acid with different strengths of nitric.

The greatest demand is for high-grade acid of between 36 and 44 deg. Bé., *i.e.*, 52 to 74 per cent acid, although as low as 30 deg. is made. Also, one grade over 52 deg. is made, which is very strong nitric saturated with N_2O and is called fuming. It is claimed to have greater oxidizing power. Nitric acid can only be satisfactorily shipped in glass carboys, although mixed acid can be shipped in steel tanks.

Production of Platinum in the United States in 1917.—According to figures compiled by J. M. Hill, of the United States Geological Survey, Department of the Interior, only 605 ounces of crude platinum was sold by placer mines in 1917. This is less than the sales in 1916 by about 100 ounces. The imports of crude platinum amounted to 31,921 ounces, not counting the 21,000 ounces of Russian crude platinum which was received by the Government late in December.

During 1917 refiners made about 33,000 ounces of platinum, 4,800 ounces of palladium, 833 ounces of osmiridium, and 210 ounces of iridium, which can be called "new metals." Of this amount about 7,400 ounces probably originated from domestic materials.

The saving of scrap platinum of all classes resulted in much larger recoveries of secondary platinum metals than in previous years, a total of 72,000 ounces being recovered, as compared with 48,000 ounces in 1916.

Potash from Seaweed in South Africa.—Mr. Gilbert F. Britten, in the course of a paper contributed to the South African *Journal of Science*, says that of the enormous growths of seaweed along the shores of the peninsula, experiments indicated that the kind known as "sea bamboo" could be utilized for the production of potash. It was found that there were not, generally speaking, very great differences in the chemical composition of the various specimens, and while South African bamboo is on the whole lower in potash content than American kelp, it is decidedly better in composition and may prove a worth-while source of potash.

Potash from Wood Ashes

Production in Michigan and Wisconsin

By C. T. EDGAR[1]

ON March 2, 1917, a number of potash manufacturers from Wisconsin and Michigan met at Wausau, Wisconsin, to organize for their mutual interests. These men formed the Northern Potash Association, which includes in its membership upwards of twenty potash plants.

The primal purpose for the meeting at this time was to deal with tariff problems, which greatly concern the future of the industry. But equally important was the need of co-operation, and the discussion of many matters in relation to an industry that has developed in somewhat mushroom fashion, yet up to the present has remained disorganized. By that I mean as well that the industry in this country as a whole has remained disorganized.

The Association referred to is sectional, and while it probably comprises the majority of those connected with the manufacture of potash from wood ashes, the total production from that source is still small, and its development has been inconsiderable compared with that of certain other fields, such as California and western Nebraska. The Northern Potash Association is endeavoring to encourage the organization of manufacturers in other sections of the country, to increase production where practicable, aand to assist the Government in any way that it can for the carrying on of the war. Its efforts have met with a gratifying spirit of co-operation.

The amount of potash produced in wood ash plants is not large, comparatively. But the number of such plants has greatly increased, and this increase has been made for the most part in the short space of two years. From three or four plants doing business in the early period of the war the number of such plants is now increased to around fifty in Wisconsin and Michigan alone.

Exact production figures for this district are not yet available. A representative number of plants, however, report an output ranging from 1500 lb. to 4000 lb. a week at each plant. The average is closer to the smaller figure. A conservative estimate would place the production of potash salts in Wisconsin and Michigan at 3,900,000 pounds annually, having a value of $1,170,000 at present prices.

The recovery of potash from wood ashes was quite an extensive method of manufacture at an earlier period. Some idea of this production may be gained from the fact that in 1850, 27,000,000 lb. were exported from Canada alone. Since 1870 the wood-ash product has been largely displaced by the mineral salts from the German deposits.

The crude form of potash produced from wood ashes is known to the trade as "potash first sorts." It consists of a soluble portion of wood ashes, obtained by a process of lixiviation. The salts are dissolved by soaking the ashes in water and drained off through a lime filter, after which the solution is evaporated and reduced to solids by heating. The product is usually sold in tight wooden barrels containing from 600 to 800 pounds to the barrel and is in the form of fused, chunky masses, having something of the appearance and hardness of stone. It absorbs moisture and will become liquid if it is exposed to the air long enough. The color is a greenish gray, with variegated hues of red, brown and blue. The coloring is due to small portions of iron and manganese, and carbonaceous impurities.

The equipment necessary for producing these salts is inexpensive and very simple. I have known many instances in which persons entirely unfamiliar with potash have constructed plants and put their product on the market within thirty or forty days after their interest was first attracted to the business.

The usual cost of a plant is about $3000. The general plan consists of an elevated platform supporting tubs, or leaches as they are called, and a "melting" room which contains the furnace and kettles. The leaches are usually from twenty to thirty in number, either square

[1]President, Northern Potash Association.

FIG. 1. POTASH PLANT AT ANTIGO, WIS. THE ASHES ARE LOADED AND REMOVED THROUGH THE SMALL DOORS ON THE SIDE OF THE BUILDING

FIG. 2. [illegible]

FIG. 3. MELTING ROOM, ANTIGO POTASH CO. ON THE LEFT IS SHOWN THE KETTLE IN WHICH THE "MELT IS COMPLETED AND THE TWO IRON MOULDS"

or round, constructed of wood with sloping metal bottoms. The round leaches, or tubs, are preferable to the square boxes, because when rotted or old they can be removed and replaced separately without interference with the adjoining leaches. They are about 4.5 ft. high and 5 ft. wide and are preferably arranged in rows on either side of the platform. This permits the used ashes to be thrown from them through little openings on the exterior walls of the building and on to wagons or conveyors, whence the leached ashes can be taken to the place of dumping.

Frequently the space through the center of the room between the rows of leaches is used for storing ashes and in the ordinary plant will conveniently store 100 tons or more at a time. Beneath the platform are metal troughs on each side running the length of the rows of leaches. The bottoms of the leaches should slope so as to be 4 to 6 in. lower at the side situated over the trough. Small holes are bored on a level with the lower ends of the leaches so as to permit the liquid to drain from the leaches into the troughs.

Before filling the leaches the filter, consisting of straw and lime, is placed on the bottoms. Rye straw is preferable. After the straw is laid on a thickness of several inches, slack lime is smeared over the surface to the extent of one inch. The leach is now ready to be filled with ashes. The ashes should be tamped down as uniformly as possible so as to insure perfect soaking. Water is run over the leaches several times a day for about four days. The ashes continue to soak up water and a process of fermentation is going on. After this period a reddish-brown liquor begins to drip from the bottoms of the leaches into the lye troughs. The ashes are watered two or more times a day and the liquor continues to drain from the leach for a period of eight to ten days after it has started to run. By that time the solution becomes weaker, the old ashes are thrown out and the leach freshly filled. The filling of the leaches is generally done in rotation so as to maintain a constant flow of lye. The strength of the ashes of any particular leach can be easily determined by the use of an alkali hydrometer, by taking the specific gravity of the lye which flows therefrom. The lye from a fresh leach will test around 20 per cent. When the test shows only one or two per cent the leach should be discontinued and the ashes thrown out.

The lye flows through the troughs into the "melting" room into evaporating pans or kettles, which for several days are kept constantly full. The evaporation is facilitated by the heat from the furnace which is usually waste heat so directed as to pass under the evaporating pans. As the solution becomes thicker it is transferred into a larger kettle, which is fitted over an enclosed brick furnace. The mass is now subjected to a powerful heat for a number of hours during which gaseous matter is driven off, combustible impurities are for the most part burnt out, and a fusion takes place. When the fusion is complete, the liquid becomes quiescent, and has a reddish glow like melted iron. It is then transferred, by means of large iron ladles, to iron pots and congeals in cakes. The pots are usually of such size as permit the cakes to fit into barrels for shipment.

The proportion of potash contained in wood ashes is not constant. The analysis of the potash salts therefore varies considerably in the proportions of potash compounds. The greater portion of these salts, however, consists of potassium carbonate, particularly in a converted form of potassium hydroxide, due to the contact with lime. An analysis follows:

Potassuim Hydroxide	65.64%
Potassium Carbonate	16.58%
Potassium Sulphate	16.03%
Potassium Chloride	.35%
Moisture and insoluble	1.40%
Alkalinity as Potassium Hydroxide (K_2O)	79.10%

The price of ashes in saw-mill localities and wood-burning communities varies from $2.00 to $6.00 a ton. About two cubic yards, not compressed, comprise a ton. Hardwood ashes are preferred to those in which the ash of soft woods predominates for the reason that the principal hardwoods apparently contain a greater percentage of potash. Woods' Dispensatory contains a table indicating the percentage of potash recovered from the ashes of various plants. It is stated therein: "Ligneous plants yield less than herbaceous, the trunk less than the branches, and the branches less than the leaves. The bark yields more ashes than the wood, and the leaves of trees which drop their foliage in winter yield more than the leaves of evergreens." Following is the table referred to:

Pine	0.45
Poplar	0.75
Birch	1.29
Beech	1.45
Oak	2.03
Box	2.26
Willow	2.85
Linden	3.27
Elm	3.9
Maple	3.9
Wheat Straw	4.18
Flax	5.0
Rush	5.08
Common Thistle	5.37
Vine Branches	5.5
Barley Straw	5.8
Beech Bark	6.0
Fern	6.2
Indian corn stalks	17.5
Sunflower stalks	19.4
Dry oak leaves	24.0
Common nettle	25.0
Black elder	25.5
Vetch	27.5
Poke	45.6
Wheat stalks	47.0
Stems of potatoes	55.0
Worm wood	73.0
Fumitory	79.0
Angelica	96.2

One difficulty of the wood potash maker is in the conservation of the ashes. He finds that the people who make the ashes are not greatly interested in saving them notwithstanding that the price may be high. Many economical improvements could be made were the business a permanent one, but the potash makers have thought it was a business that would be killed by foreign competition some time following the close of the war and are therefore unwilling to make improvements.

Wausau, Wis.

Fulton's Electric Zinc Furnace

THE METALLURGICAL LABORATORIES, Inc., has been experimenting for about a year and a half with the zinc-smelting process devised by Dr. Charles H. Fulton of Case School of Applied Science, and patented by him early in 1916[1]. During the twelve months following September, 1916, Dr. Fulton personally directed the experimental work at East St. Louis, with satisfactory results. At the present time the plant contains an intermittent furnace of commercial size, operating on various oxide and silicate ores, determining the proper mixtures for briquetting, the current requirements, and the condenser design capable of liquefying the tremendous volume of vapor produced. The furnace now in operation is practically that described in patent No. 1,242,337 (Oct. 9, 1917), which, together with others recently granted (1,242,339 to 41, and 1,249,061), gives a large number of details concerning their experiments.

With reference to Fig. 1, the furnace is an electric resistance furnace, consisting of the movable cylindrical steel shell (1) closed at the top, lined with refractory material, and the open bottom resting on a fixed base *B*, the passages 10 being heated by a gas flame. The dried ore, with suitable binder, is formed into briquets which constitute the resistors, and the electric current passing therethrough generates sufficient heat to raise the interior to such temperature as is necessary for the reduction of the zinc compounds and the vaporization of the metal. The finely divided zinc-bearing material (ore, blue-powder, or ashes) is mixed with pulverized coke for a reducer, and sufficient binder is added (tar or hard-coal tar pitch) to thoroughly coat the particles.

Coke is the best reducer because it contains little volatile matter to be driven off preliminary to distillation, and gives off no gas during distillation. The particles also retain their form during the process, thus insuring the continued stability of the briquet. The relative proportions of coke and ore should be such that sufficient porous material will remain at the end of the heat to insure substantially the original volume of the briquet, and constitute from 40 to 50 per cent of the original weight. Binder to the amount of 12 to 15 per cent of the weight of the ore plus coke is sufficient if the latter is moderately fine, i.e. will pass through a 10-mesh screen. The proper determination of the coke size is important, as fine coke produces strong briquets, but of low electrical resistance.

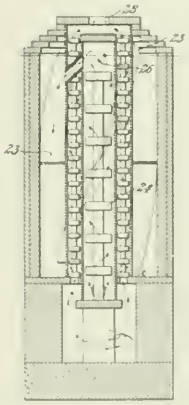


FIG. 5

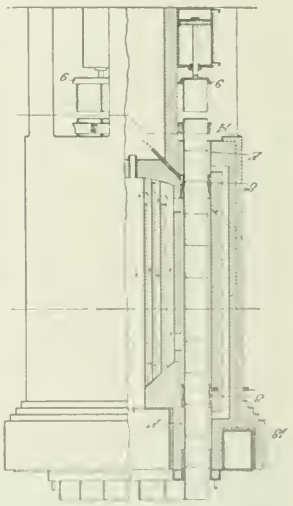


FIG. 6

The hot mixture is compressed into rods, 12 inches in diameter and six feet long at a pressure of from 500 to 1000 lb. per square inch. They are then preheated in order to coke the binder and drive off the hydrocarbons before distillation begins. The briquets are properly supported during this process in order to maintain their shape; a neutral or reducing atmosphere is also essential to prevent the coke at the surface from burning and loosening into a friable layer.

The briquets may more easily be made in shorter sections, and cemented together at the ends by a mixture of 40 per cent of coal-tar pitch, and 60 per cent of fine graphite. In any case the final briquet is placed on end upon an electrode energized through leads built into the fixed bottom of the furnace. Top and bottom connections for a 3-phase star connection are shown in Figs. 2 and 3, the connectors being made of graphite (or of the ore-coke mixture) and pinned

[1] A short description of the original patent was given in this Journal Feb. 1, 1917, p. 158

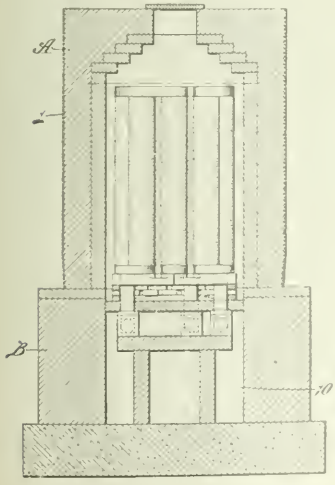


FIG. 1

FIG. 2

FIG. 3

FIG. 4

to the top of the resistor as shown in Fig. 4. In this diagram 3 represents a filling of fine graphite; the construction being designed so that there is small danger of an open circuit at these points due to differential shrinkage of adjoining columns.

In operation, the baked briquets are assembled upon the bottom electrodes, and the top connections made. A preheated retort *A* is lowered over the whole, and current switched on. The energy input is relatively small until the whole interior of the retort reaches a temperature of from 700 deg. to 800 deg. C. when the current is rapidly increased until the distillation point is reached. The products of the reaction, zinc and carbon monoxide vapor in equal volumes, are drawn off in a quite pure condition through openings at the top of the base and discharged into a suitable condenser set nearby. A complete cycle requires 5½ to 6 hr., when the distillation is practically complete.

As can readily be imagined, the problem of condensing the zinc vapors is of extreme importance. Several designs of electric zinc furnaces can produce zinc vapor in large quantity, but none of them has been able to produce the proper yield in liquid metal —the vapor apparently solidifies as the solid blue-powder without passing through the liquid phase, much as happens in the formation of frost. In order to condense from a vapor, the temperature of the gas must be lowered beyond the boiling point of zinc at the partial pressure of the mixture, 870 deg. C. at ½ atmosphere, which exists when Zn and CO are present at equal volumes. The liquid product must not solidify; the absolute temperature minimum is therefore the melting point of zinc (419 deg. C), while the working minimum is more like 550 deg. C. or 600 deg. C. Another important consideration is the amount of surface necessary for the condensation of a given quantity of vapor; so-called "nuclei of condensation" are necessary. That is, if there be provided in a space a large number of points or "nuclei" upon which the vapor has condensed into a liquid, these small particles of liquid already formed facilitate the further condensation of the vapor. Some surface must now be provided for the "nuclei" to gather upon, and the liquid to coalesce into droplets.

As remarked above, electric smelting of zinc has produced considerable "zinc frost" or blue-powder. This may be due in some cases to the production of a zinc vapor mixed with a variety of other gases. The partial pressure and boiling point of zinc in the mixture is therefore lowered, and consequently the temperature limits of successful condensation are more narrowly restricted. Again, local hot spots or small arcs in the charge may vaporize minute quantities of other metals or metalloids which solidify almost immediately, forming a plethora of condensation nuclei. Or due to slightly oxidizing conditions existing in the condensing gases at the reduced temperatures, the tiny droplets may become sufficiently oxidized on the surface that they do not coalesce into a liquid.

Whatever may be the actuality of these controversial points, the condensers operating on Dr. Fulton's retorts will have to overcome them, and in addition absorb and radiate a great quantity of heat continuously. Supposing each retort to hold 12 briquets, each weighing about 600 pounds, and containing about 20 per cent zinc, which is entirely distilled and condensed in six hours, liquid zinc would form at the rate of 240 pounds per hour. Not counting the amount of heat radiated by the hot mixture of gas cooling from the temperature of the retort (1000 deg. C. to 1300 deg. C.) to that of the condenser (600 deg. to 800 deg.) the latent heat of vaporization of the zinc at the lower temperature (1,051 B.t.u. per pound) will amount to 252,000 B.t.u. per hour. Although Dr. Fulton's process gives a cleaner vapor than many other proposed schemes, actual figures on the real condensation accomplished would be very interesting.

Two condenser designs are illustrated in the patents, one being shown in Fig. 5. It consists of a central shaft containing several baffles (24). The gases from the retort ascend through this shaft, then into the outer chamber 23 where they are deflected up and down by spiral partition walls, the uncondensed gases finally escaping through openings 26, where the carbon monoxide may be utilized. In order that the condenser may operate within the rather narrow temperature limits necessary, the annular checker chamber between these two chambers may be heated by gas flames (or cooled by air blast as necessary) entering below and escaping through the top 28.

A continuous furnace and process is also described and patented (1,242,339 and 40) illustrated in Fig. 6. The annular furnace contains a series of briquets heated by the passage of electric current between the electrodes 8 and 8*a*, where sliding contact is maintained by granular graphite. As distillation proceeds, fresh briquet sections are fed into the distillation zone by the action of a plunger 9 and supporting clamp 14. Spent hot electrodes are removed from the top and set in the trough 18 alongside freshly made sections, to dry the latter. Further baking is effected as the briquet passes through chamber *E*, where a gas flame is maintained, together with chamber *F;* this also acts as a seal preventing oxygen entering the distillation chamber. The products of the reactions are drawn inwardly to the central condensing chamber shown.

These novel processes have many unique features which apparently offer advantages. The temperature of distillation can be controlled either by voltage regulation, or by changing the speed of the briquets travelling through the continuous furnace. This should lend itself to the production of zinc relatively free from cadmium or other impurities, as the cadmium-rich product could be collected and withdrawn early while the furnace is at a low temperature. The time of distillation, heat input and labor cost have been reduced to a minimum.

High-Grade Abrasives—Tremendous expansion in manufacturing in 1917, particularly in the steel and metal industries, is reflected by the increased production of high-grade abrasive materials in the United States. A preliminary compilation by Frank J. Katz, United Seates Geological Survey, of reports on the production of emery, corundum, and artificial abrasives in 1917 indicates a total of 72,276 short tons, valued at $8.325,312, which is an increase of 33 per cent in quantity and 172 per cent in the value as compared with 1916. About 80 per cent was artificial abrasives.

Stellite

Alloys of Cobalt, Chromium, Tungsten and Molybdenum

By Elwood Haynes

It is a noteworthy fact that the metals found in their native state on the surface of the earth are, generally speaking, extremely rare. Besides meteoric iron and native copper, they include gold, silver, mercury, and the metals of the platinum group. If Nature produced other metals during the formation of the earth's crust, they have long since combined with other elements, and exist only as compounds, chiefly oxides, sulphides, arsenides, carbonates, chlorides, etc.

It is extremely desirable, however, to have for use metals or alloys which remain permanent under atmospheric conditions, and at the same time have such physical properties as will enable them to be manufactured into instruments and utensils for daily service. Metals which are not at all permanent in the air, such as iron, lead, mangenese, etc., produce compounds with oxygen or sulphur which remain practically unchanged under ordinary natural conditions for many centuries, but these compounds are not workable, nor in any way suitable to direct manufacture into implements for daily use. Their physical properties, such as strength, hardness, and workability, are not such as would recommend them for such instruments. Copper, alloyed with zinc, produces brass, and olloyed with tin, produces bronze, but none of its combinations is permanent in the air, and all of its alloys are inferior in strength and hardness to steel.

The so-called "noble metals" with the exception of silver, are permanent in the air, but are so rare that implements made of them would be extremely costly, particularly if of any considerable size.

Desirable Qualities Sought in New Alloys

It was with a view to producing an alloy which would combine the permanence of the noble metals with the strength and hardness of steel that the writer made a long series of experiments, which finally resulted in the production of a series of such alloys.

As early as 1899, an alloy was produced by heating the mixed oxides of chromium and nickel with metallic aluminium. A small button was obtained which showed considerable malleability when cold and when polished exhibited a bright luster which was not dimmed when the metal was boiled in either strong or dilute nitric acid. Moreover, the acid showed not the faintest color after such test. This alloy was somewhat harder than untempered steel, and could be readily worked under the file or in the lathe.

The mixed oxides of cobalt and chromium were afterward reduced by the same method, but the little pellets of the alloy thus produced were thrown from the crucible by the violence of the reaction. A few of these were collected, and found to be very much harder than the corresponding nickel alloys. They showed the same resistance to nitric acid and were only attacked very slowly by hydrochloric and sulphuric acids.

Later, the mixed oxides were reduced by means of carbon, and it was found possible to cast the alloy into bars which showed remarkable strength, rigidity, and hardness, as well as complete immunity to all atmospheric influences. Polished samples of the alloy were exposed to the fumes of the chemical laboratory for months, and in some cases their surfaces became covered with a deposit of ammonium chloride, but this could be easily rubbed or washed away, and the alloy showed the same brilliant surface as before.

These binary alloys of cobalt and chromium were so hard that they would take a cutting edge, and could be used in the place of steel for pocket-knife blades and table knives. They were found to be malleable at a bright orange heat, even when the chromium content rose to forty-five per cent or more. These high chromium alloys were very hard to forge, but after forging into pocket-knife blades, for example, they showed extremely fine grain, high elasticity, and a hardness equal to that of the best quality of steel pocket-knife blades. The permanence, general utility, luster, and color of these blades are very remarkable.

An Alloy Rival of Steel

This alloy may be truly termed steel's first rival, since it constitutes the first metallic combination yet discovered, so far as the writer is aware, which takes and holds an edge at least equal to that of the best steel, and at the same time it can be produced in almost any form in which steel is utilized. It is of course much more costly, owing to the high price of its constituents. This, however, does not preclude its use for the following articles: a. table knife blades; b. pocket cutlery; c. surgical instruments; d. dental instruments; e. small evaporating dishes; f. spoons, forks and scissors. Lancets made of this hard alloy are now in use by many expert surgeons, and are proving highly satisfactory for this purpose, since they are immune to all antiseptic solutions employed in surgical work, and at the same time take a keen edge, equal to that of the best tool steel.

The first paper was read on the binary alloys of cobalt and chromium, before the American Chemical Society, in 1910, at San Francisco.

ARTICLES MADE FROM STELLITE

Later, the elements tungsten and molybdenum were introduced into this alloy, either of which increased its hardness to a remarkable degree. In fact, alloys of this character can be made so hard that they will scratch any steel yet produced.

Nature and Properties of the Alloys

Just what is the nature of these combinations has not yet been fully determined. They seem to consist, however, of a cement of the hard cobalt-chromium alloy, which binds together minute crystals, possibly composed of the double carbides of chromium and tungsten or chromium and molybdenum. The above is little more, however, than a conjecture, as no real proof of such an assertion has yet been made.

These alloys can be readily cast into various forms, and melt at a lower temperature than the binary alloys of cobalt and chromium. The most remarkable property of these triple alloys is their ability to retain a cutting edge at high temperatures, and it is for this reason that they excell all high-speed steels in their ability to perform rapid work on the lathe.

Lathe speeds which would instantly destroy the edge of the best high-speed steels can be readily maintained with stellite tools without injuring the cutting edge. This advantage is so pronounced that stellite is coming into very extensive use as a substitute for high-speed steel tools, notwithstanding its comparatively high price. Machine shop superintendents and production men generally, are keenly alive to the fact that because other costs in the manufacture are so much greater than that of the tools, they are fully justified and save large sums of money on labor, equipment, floor space, and so forth by using highly efficient tools.

The following articles have been made from the hard alloys: lathe tools, milling cutters, saws, drawing dies, boring tools, drills, etc. These tools must be cast to the proper form, as they can not be forged nor otherwise manipulated except by grinding. At first sight, it would seem desirable that the tools should be of such a nature that they could be tempered and forged, but a moment's reflection will render it evident that such a property would be detrimental, since in order that it might be forged, it would be necessary that it should soften under heat and would thus lose its most valuable property. The same would be to a certain extent true regarding tempering or hardening, since it is the inherent stability of the alloy at all temperatures which gives it its highly desirable qualities as a lathe tool.

At the instant of casting, and just as the metal is changing from the liquid to the solid state, minute crystals of extreme hardness are formed, and these crystals remain unchanged in their properties under practically any series of temperatures below the melting point of the alloy. Prolonged annealing does not soften it, and it is not hardened by heating it to a high degree and quenching in water. It does not take up carbon to any appreciable degree, even when surrounded by carbonaceous material in a closed vessel for days at a bright orange heat, say 1000° C. or more.

All of the polished alloys, when heated in an open fire, take on a thin film of oxide, which finally terminates in a deep blue-black color. This oxide is so firmly adherent that it absolutely prevents further oxidation of the metal, so that even though the sample may be heated for days at this temperature, it will not show the slightest gain or loss.

Thus far, the lathe tools, surgeons' scaples, and dental instruments are the only forms of stellite which have been placed on the market. It is hoped, however, that other articles will soon be forthcoming. Among these will be table and pocket cutlery.

Table knives made of alloy have been in use for a period of six years, and show not the slightest tarnish. In fact, they retain their original flash and brilliance far better than any known alloy. The wear on these knives is remarkably slow. A teaspoon which was weighed before and after six months' use showed no weighable loss whatsoever. At the rate of wear after one year's service it seems certain that the spoon will last at least a thousand years and still be serviceable.

Effect of Acids and Alkalis

All of the alloys are attacked by sulphuric, hydrochloric and hydrofluoric acids or by mixtures of the same. They are also attacked by the fused alkalis. As already stated, they change color at a dull red heat, but after once becoming coated with oxide, they undergo no further change and may be maintained for days at 1000° C. without loss or gain in weight. They are practically immune to all organic acids in solution, as well as to all antiseptic solutions, including bichloride of mercury, phosphoric acid, etc. They are likewise unaffected by solutions of the caustic alkalis, and are practically immune to nearly all neutral chemical solutions, including ammonium chloride, which so readily attacks iron and steel.

Table-knife blades made of the alloy remain brilliant and untarnished after years of service. The cutting edge of the table knife wears very well indeed, and from the experience already gained, a set of stellite knives will, if properly taken care of, last at least a generation for ordinary service.

The elastic limit of hammered stellite is not equal to that of tempered steel, but it sufficient for all ordinary requirements. In stiffness it is superior to steel and in fact, to any other alloy or combination in practical use. Table-knife blades can therefore be made quite thin and still be stiff enough for practical purposes.

Kokomo, Ind.

Spanish Pyrites in Restricted List.—Pyrites are included in the list of articles that cannot be imported, except a tonnage not exceeding 125,000 long tons, prior to October 1, 1918. A meeting of the domestic pyrites producers was held in the Council of National Defense Building, Washington, March 11. In order to help out the shipping situation, it was announced that the estimated imports for the next six months would have to be reduced; and the committee appointed to consider this matter recommended that the reduction in imports be made gradually, as follows: April, 40,000 tons; May, 30,000 tons; June, 20,000 tons; July, 15,000 tons; Aug., 10,000 tone; Sept., 10,000 tons. The importance of making up this loss in Spanish pyrites by the increased production of domestic pyrites to the greatest extent possible is made obvious by the above. It is understood that licenses for importing Spanish pyrites loaded after Apr. 15 will be issued only on new applications, in connection with the 125,000 tons of Spanish pyrites allowed for importation between that date and Oct. 1, 1918.

Some Problems in Evaporation and Drying*

By P. B. Sadtler and F. M. de Beers

In our work of designing and building evaporators for all kinds of service we are often presented with new operating conditions, new results desired and new chemical engineering problems that are extremely interesting. While we recognize the necessity and importance of a thorough training and knowledge of the theoretical side of this business, we have also been shown that the important thing, so far as the satisfaction of our clients and the advancement of the chemical industry are concerned, is the practical application of these theories usually based upon some previous experience that we have analyzed as far as possible on the basis of these theories.

It often happens that a process will be marked out in a laboratory and the evaporation part of the process will appear to be very definite as regards certain important features, but our analysis of the result will introduce factors that never appeared at all in the laboratory. For example, we had a client who wanted to concentrate a certain solution beyond the saturation point of the salt contained in the same, with the intention of precipitating that salt in the evaporator. The solution was concentrated on a fairly large scale in the laboratory, and the crystals were perfect in form and rather large, somewhat larger than dairy salt, for example.

Our analysis of the problem from a rather practical standpoint led us to believe that, under actual operating conditions on a large scale, the crystals formed would be very small. This was not because all crystals formed in the particular type of evaporator we intended to use are small, as in most cases the crystals are well formed and of a size much larger than we said would be the case with our customer's product. Our reasons for saying the crystals would be small were as follows: The solution itself and the mother liquor, as the crystallization began, were both easy boiling solutions, practically as fluid as water, with no viscosity, and very few impurities present. The specific gravity while high did not give a liquor having the physical qualities of sugar solutions, caustic soda, etc. The salt formed was very heavy. The circulation in the type of equipment used is very rapid. We reasoned that there would be no chance for the crystal to build up, because of the rapid circulation and the molecular weight of the salt formed. The circulation would remove it from the heating or concentrating zone quickly. The solution being very fluid would not tend to keep the crystals in suspension and the tendency to quickly settle out was, of course, assisted by the high molecular weight of the salt itself. In this way the small crystals would separate from the solution circulating through the tubes and there would be no chance of their becoming larger. With a viscous solution and where the salt formed is not very heavy, the crystals stay in suspension until they are large enough to overcome these factors, when they settle out, notwithstanding the rapid circulation. While they are still small, they remain in suspension and are carried through the heating tube repeatedly and build up because of evaporation produced, and become larger with each passage through the tubes, until they are large enough to overcome the effect of viscosity and circulation when they settle out of the path of circulation. This is the case where sodium chloride crystallizes out of a caustic soda solution, or from a glycerine solution.

Referring back to the problem of our clients, we reasoned that the crystal first formed would not be circulated again, and consequently would be small, and we designed our equipment accordingly. Most any form of salt separator can be used where the crystals are large, but with very small crystals many of the more efficient types of separators or filters have to be discarded.

The filters we put in were not as efficient as other types we make, which are suitable for large crystals, but we believed they were the only style to use if small crystals resulted. Fortunately for us our conclusions were correct, as the crystals were exceptionally small—nearly as fine as talcum powder, and if we had followed the laboratory data alone, and used a filter suitable for large crystals, our client would have had no end of trouble, and he probably would have condemned the entire evaporating apparatus.

This is simply an illustration of the value of applying scientific data to any design of evaporator, and the necessity of occasionally disregarding a more efficient type of construction in order to have an equipment that will be commercially satisfactory.

We often have to advise against the use of multiple effect economy, or to limit the number of effects because of certain physical properties of the solution being concentrated or because of the chemical characteristics of materials in solution or suspension. We know, for example, that a certain minimum effective temperature difference is necessary for efficient operation. The capacity in pounds of water evaporated per square foot per hour is directly proportional to this effective temperature difference, which is the difference between the temperature of the vapor or steam being condenssd and the temperature of the vapor formed from the liquid being concentrated—minus the excess boiling temperature of the solution. The capacity is also proportional to the velocity of the vapor on one side of the tube and to the velocity of the solution on the other side.

In most types of evaporators the velocity of the solution is caused by the heating or evaporating of same and the greater the temperature difference the greater the velocity of the solution. In this way the capacity of a tube is greatly reduced, as the temperature difference goes down and the first cost of the evaporator becomes prohibitive, notwithstanding the apparent saving in steam because of the greater number of effects. As the temperature difference and velocity of circulation are reduced, there may be an opportunity for materials to come out of suspension or solution and deposit on the tube, which would not form there if the circulation were better. Any solution that has a tendency to foam will give less trouble with a greater temperature difference per effect, and this may limit the number of effects we can use, although we have found a way to overcome this trouble to a large extent by following a certain scheme of operation. Where a solution has a boiling point above that of water we must have an effective temperature difference above this excess or we will not do any work. This matter of excess boiling

*Abstract of a paper presented at the St. Louis meeting of the American Institute of Chemical Engineers, December, 1917

temperature often limits the number of effects we can economically use from a commercial standpoint.

It is evident, therefore, that any recommendations we make as to type, number of effects, auxiliaries, etc., must be first based on a complete knowledge of the chemical and physical properties of the solution to be concentrated. We must have the complete confidence of our client, otherwise our work can only be half done. We also believe in explaining our own reasons for every step in the development of the final design, which include reasons based entirely on practical experience with some similar material. I would like to explain in detail some of the problems we have worked out, but in all fairness to our clients I do not feel privileged to refer to specific problems.

The results of our work in every case belong to our client, and no one but that client should know what he is doing.

While we have a large amount of practical data, and while there are a few excellent books on the theoretical side of evaporator design, we have often wanted some conclusive evidence in connection with the determination of certain constants and variables that does not seem to be available anywhere. I am pleased to take this opportunity of announcing that an arrangement has been made between our company and the University of Michigan, whereby we are giving a laboratory to the University, which will co-operate with us in securing fundamental scientific data relating to evaporators. Dean Cooley and Professor Badger, as well as the President of University and the Board of Regents, have co-operated with us to the fullest exent, and within a short time we expect to have some of these factors definitely determined which we now base entirely on practical experience backed by scientific reasoning. All data obtained that is of interest to the scientific world in general will, of course, be published. The establishment of this laboratory should be most valuable to students in chemical engineering, as the first purpose of same is for the benefit of the students, and our own work will only be done when the laboratory is not needed for the student work. The laboratory is housed in the old boiler house of the University, located in the southeast corner of the campus. It occupies half of the building, the evaporators themselves being erected in the boiler room.

This laboratory will be used to work out government problems, also commercial problems of responsible individuals or companies. The main purpose of the plant from our standpoint, however, is to give us a place where we have all the equipment and facilities for the determination of evaporation factors, with all variables eliminated except the one we are working on. We wish to correlate theoretical and practical data and do not intend to repeat the work done by such eminent authorities as Dr. Hausbrand, for example. We intend to use to the fullest extent the results of his work and may later check up certain things, largely to gain the knowledge that is only possible through such experiments. Our equipment is large enough to carry on our experiments on a commercial scale, with the personal error factor very largely eliminated because of the quantities handled. We want our results to be commercially valuable, and among the things we are going to do are the following:

Determination of velocities of steam, vapor and liquor in various standard types of evaporators and under various normal operating conditions.
Value of catchalls of various types.
Amount of loss of liquor by entrainment and by foaming and best means of overcoming same.
Separation of crystals from mother liquor.
Location of non-condensible gases and amount of same from various commercial solutions, also source of same and best means for their removal.
Determination of loss of vapor with efficient removal of these gases.
Determination of volume removed at various stages of the work in a multiple effect, etc.
Conductivity factors in heaters and surface condensers under varying conditions as to velocity, viscosity, size and shape of tube, etc.
Constants based on work done per square foot of heating surface with the following variables:
Effect of velocity of steam or vapor.
Effect of velocity of liquor.
Effect of temperature difference.
Effect of vapor density.
Effect of crystallization.
Effect of scale on tubes.
Effect of temperature of entering liquor.
Effect of materials in suspension.
Effect of materials in solution.
Effect of excess boiling temperature.
Effect of viscosity.
Effect of evaporate type.
Effect of density of liquor.
Effect of tube length and diameter.
Effect of tube depth in a horizontal tube machine.
Effect of downtake area and location of same.
Effect of metal used for heating surface.
Effect of surface of tube on capacity.
Effect of protective coverings.
Effect of moisture in steam.
Effect of hydrostatic head.
Effect of area of liberating surface, etc., etc.
Liquor level regulators and their usefulness.
Determination of effect of heat of solution when concentrating a salt solution.
Best method of regulating size of crystal formed.

These are only some of the things we have planned to do, but this may give you an idea of how the laboratory will be used. We feel we just about know a lot of these things, but want this conclusive confirmation or correction of our own theories, which are now largely substantiated by actual results. We would be very pleased to receive suggestions from members of the Institute as to data that should be obtained as regards general or specific evaporation problems. We expect later to expand the laboratory so it will include drying machinery, filtering and pressing equipment, etc. While we are called upon to work out a good many chemical engineering problems that do not relate to our evaporators, the purposse of this laboratory for the present, at least, is simply to secure evaporation data during such time as it is not needed for student work.

Swenson Evaporator Co.,
Chicago, Ill.

Portugal Takes Over Mines During War.—According to Consul General W. L. Lowrie, Lisbon, a decree of the Portuguese Government dated March 14 reserves to it the sole sale and export of all minerals found in the country that are of value in war industries. The Government, through the Minister of Labor, upon recommendation of the Department of Mines, will fix the prices at which the minerals affected by the decree will be sold. Wolfram and chromium are included in the provisions of the decree, and consequently all exportation of these minerals is prohibited. All stocks at the mines or elsewhere must be declared to the Department of Mines under penalty that the mineral will be seized.

Synopsis of Recent Metallurgical and Chemical Literature

Aromatic Nitriles by Catalytic Dehydration.—A new method of preparation of aromatic nitriles in the vapor phase has recently been described by ALPHONSE MAILHE in *Comptes-Rendus, de l'Académie des Sciences*, Jan. 7, 1918, vol. 166, pp. 36-38.

It is known that on treating esters by ammonia, these are converted into amides:

$$R.CO.OR' + NH_3 = R.CONH_2 + R'OH.$$

on the other hand, amides yield nitriles by dehydration in the liquid phase in the presence of phosphoric anhydride or certain catalysts (pumice, sand, alumina, graphite).

$$RCONH_2 = H_2O + RCN.$$

Amides, however, are solid substances with high boiling points and, consequently, difficult to pass over catalysts in the form of vapor. The question arose whether the action of gaseous ammonia (NH_3), reacting with esters in the vapor phase in the presence of dehydrating catalysts, could not give the two reactions given above simultaneously and, thus, lead directly to nitriles. This assumption has proved to be correct and has been substantiated by experiments.

On directing methyl benzoate ($C_6H_5.CO_2.CH_3$) vapors together with gaseous NH_3 over thoria heated between 450-470 deg. C., a gas is collected consisting of excess NH_3 and H_2, and a liquid which separates into two layers: the one, aqueous, giving an aldehydic reaction; the other, on being subjected to distillation, yields a small quantity of CH_3OH with a little CH_2O held in solution therein, and another fraction which distills between 181-191 deg. C. Above 191 deg. C. the residue left was insignificant in amount. The portion boiling between 188 and 191 deg. C. possesses a strong odor of bitter almonds. With chloride in hydrochloric acid solution, it gives immediately a crystalline yellow precipitate, pointing to the presence of benzonitrile $C_6H_5.CN$ which boils at 190-191 deg. It has been identified by subjecting it to hydrogenation over reduced nickel at 180-200 deg. C. whereby it is converted into $C_6H_5.CH_2$ and a mixture of benzylamine and dibenzylamine.

As regards the aldehydic reaction pointed out above, it is due to the decomposition of a small amount of methyl alcohol into H_2 and formaldehyde:

$$CH_3OH = H_2 + H.COH.$$

It will be seen that the simple decomposition of methyl benzoate by gaseous NH_3 in presence of thoria, constitutes an easy method for the production of benzonitrile.

$$C_6H_5CO.OCH_3 + NH_3 = C_6H_5.CN + H_2O + CH_3OH$$

Up to 400 deg. C. this reaction does not take place in an appreciable manner. At about 430-440 deg. C., it is becoming important and, at 470-480 deg. C. it is almost total.

In the case of ethyl benzoate the reaction leads also to benzonitrile.

Toluidic esters behave similarly to benzoic esters, yielding the corresponding toluidic nitriles:

$$C_6H_4\begin{matrix}CH_3\\CO.OR\end{matrix} + NH_3 = C_6H_4\begin{matrix}CH_3\\CN\end{matrix} + H_2O + ROH$$

The methyl-ester of ortho-toluidic acid which boils at 207 to 208 deg. C. yields ortho-tolunitrile which boils at 203 deg. C. The ethyl ester of paratoluidic acid leads likewise to paratolunitrile. Phenylacetic acid readily gives ethyl phenylacetate and the latter, when passed in the form of vapors together with NH_3 over thoria at 450- to 460 deg. C. yields benzyl cynide $C_6H_5CH_2CN$. By this method which seems to be possessed of a very general character, the use of potassium cyanide is eliminated. The yields of aryl nitriles are said to be good.

Dimethylaniline by Catalytic Dehydration.—A new method of preparation of mono-methyl-aniline and dimethylaniline was presented to the French Academy of Sciences by A. Mailhe and F. de Godon and published in *Comptes-Rendus*, 1918, March 18, vol. 166, pp. 476-469.

It is known that dimethylaniline is an intermediate used in the production of a large number of artificial "coal-tar" dyes. Monomethylaniline is less used for this purpose. In modern industrial practice for the preparation of these two bases, aniline is alkylated by means of methanol. $C_6H_5NH_2$ and CH_3OH are heated together with HCl or H_2SO_4 in autoclaves at 180 deg. C. in the case of monomethyl-aniline, and 230-235 deg. in that of dimethyl-aniline, with increase of pressure to 30-35 atmospheres. Upon termination of the reaction, the reaction mixture in the autoclave is blown out by means of compressed air into a kettle containing caustic soda in order to liberate the base which is driven out by means of steam. This operation is then followed by rectification. By noting also that the mixture of CH_3OH and H_2SO_4 must be prepared in advance, prior to the reaction proper, under special conditions and that the operations of charging and heating the reaction vessels require certain precautions, it will be seen that the "technique" of this reaction is rather complicated.

The reactions of formation of these two secondary and tertiary bases from CH_3OH and $C_6H_5NH_2$ may be considered as dehydration reactions:

$$C_6H_5NH_2 + CH_3OH = C_6H_5NHCH_3 + H_2O.$$
$$C_6H_5NH_2 + 2CH_3OH = C_6H_5N(CH_3)_2 + H_2O$$

The hypothetical consideration that, on subjecting a mixture of aniline and methyl alcohol in the vapor phase to the action of a dehydrating metallic oxide at a suitable temperature and, thus, to make the reaction proceed in the sense indicated by the above equations, has been given substantial proof by experiment.

On directing a mixture of aniline vapors and methyl alcohol vapor over thoria heated between 400 and 450 deg. C., a notable proportion of mono- and dimethyl-aniline has been obtained. But part of the $C_6H_5NH_2$ had not been acted upon.

Zirconia, ZrO_2, displayed a behavior almost analogous to that of ThO_2.

Alumina, Al_2O_3, seems to be best adapted for effecting this preparation of the secondary and tertiary bases. On directing over this catalyst a mixture of aniline and a slight excess of methyl alcohol (both in the state of vapor), at once a mixture of monomethyl- and dimethyl-aniline has been obtained with only insignificant traces of the original aniline. In this reaction a small amount of methanol is destroyed by dehydration with secondary formation of methyl ether.

$$\begin{matrix} CH_3\overline{|OH} \\ CH_3\underline{|H} \end{matrix} \longrightarrow \begin{matrix} CH_3 \\ CH_3 \end{matrix} > O + H_2O$$

The excess of alcohol is condensed with the bases and can be recuperated by rectification of the condensate. When conversion of the aniline-alcohol is complete, the water and alcohol are separated from the free bases by decantation which latter are then subjected to distillation. In this manner a mixture of monomethylated and dimethylated aniline is obtained.

It was of importance to verify whether methylation of monomethyl-aniline could be carried so as to convert it totally into the dimethyl-derivative. For this purpose a mixture of monomethyl-aniline and methyl alcohol was directed in the state of vapor over Al_2O_3 heated to 400 to 500 deg. C. The secondary base was converted into tertiary base.

In these operations the alumina assumes after a certain time a yellowish coloration which later darkens to a brownish tint. Its catalytic power is slightly diminished. A simple calcination is sufficient to make it reassume its pure white color as well as its original activity.

The extreme simplicity of the preparation of these two important bases is evident. The manipulations of the raw materials are reduced to a minimum and no longer require the application of high pressures and acids which had a strong corroding effect upon the cast-iron autoclaves. It is true that this inconveniency has since been avoided by using cast-steel autoclaves lined with an acid-proof enamel. Besides, the use of compressed air, sulphuric acid and caustic soda and the driving-out by steam are steps no longer required. Whereas in present-day manufacture aniline must be very pure and contain not more than 0.5 per cent of H_2O, the alcohol be free from acetone which, owing to its high volatility, subjects the autoclaves to excessive interior pressures, in the new method the aniline may contain a certain proportion of water without detriment to the yield of the reaction, and the presence of a rather great proportion of $(CH_3)_2CO$ in the alcohol entails no inconveniences.

Size of Metallic Crystals.—Dr. G. H. Gulliver presented a note on grain size before the March meeting of the Institute of Metals (British) in which he observed that there is a fairly widespread belief on insufficient evidence that under favorable conditions the crystal grains in a metallic mass approximate to a uniform size and uniform compact shape. However, a cursory examination of a micrograph shows that there is a large variation in the size of the grain sections—too large, in fact, for the satisfactory employment of a mean if the sections were disconnected quantities, which, of course, they are not. Therefore the real significance of the term "grain size" is "mean granular volume." Dr. Gulliver presents a mathematical treatment of the subject, confining his attention to the relation between the mean volume of a grain and its mean area of section, when the material shows only one kind of structural constituent. With grains of approximately equal volume (varying say plus or minus 10 per cent), and approximately the same compact shape (that is to say, being polyhedrons of from ten to sixteen faces, with a variation of plus or minus 5 per cent among the corresponding diameters), a micrograph containing at least 200 crystalline sections would show a nearly constant number of grain sections, from whatever part of the mass it is obtained. The approximate relation of the two-dimensional grain size to the mean granular volume is shown by the following equation:

$$\text{Average granular volume} = \frac{3}{2}\left(\frac{A}{n}\right)^3$$

where A is the cross-sectional area of the section under examination, and n is the mean number of grains appearing in that section. Thus the fraction A/n is the area usually called "grain size." As before noted, if the grains are approximately equal and equi-axed, random sections yield a nearly constant grain size. The converse of this statement is not necessarily true, and a constant two-dimensional grain size might only indicate a recurrent form of distribution. A ready means of detecting a gross departure from uniformity is to measure the areas of the grains of a suitable micrograph, and compare the maximum with the mean. The maximum value of this ratio for equi-axed crystals is shown to be 1.7 with a probable plus or minus variation of 20 per cent—roughly, to lie between 1.5 and 2.0. These ratios may usefully be employed as a criterion of uniformity of the grains, and its value in several measured photographs has been found to lie between 3.5 and 5.0, the higher values being obtained after longer periods of annealing. In other words, the grain size was far from uniform, and annealing increased the degree of non-uniformity.

Manufacture of Crude Sodium Manganate.—The *Journal of the Chemical, Metallurgical and Mining Society of South Africa* contains a short description of this subject by F. Wartenweiler. A laboratory process was worked up in view of the shortage of easily soluble oxidizers for use in the reduction works of the Rand and crude sodium manganate was found to be an acceptable substitute for the nearly pure potassium permanganate formerly used. The reactions used are either

$$3MnO_2 + 2NaOH = Na_2MnO_4 + Mn_2O_3 + H_2O$$

or

$$2KNO_3 + 2MnO_2 + 4NaOH = 2Na_2MnO_4 + 2KNO_2 + 2H_2O$$

Ferruginous manganese dioxide ore (pyrolusite) from Pretoria furnished the manganese and analyzed about 40 per cent Mn. Commercial caustic soda and potassium nitrate were also used. The combination found most effective in the first equation was 1 part by weight of the 40 per cent manganese ore to 1.44 parts caustic, and 1 part of ore 1.1 part caustic and 0.4 parts nitre for the second. It is necessary to use a large excess over the theoretical requirement of caustic soda; anything less than 110 per cent will give no manganate. The work was carried on in a four-hearth brick muffle-type calcining furnace ordinarily used for calcining acid treated zinc-gold precipitate. No particular difficulty is encountered in producing the material in large quantity. A product containing 28 per cent sodium manganate was made by the first equation as follows: The ore was finely ground in a ball mill and the chemicals well

mixed in 500-pound batches before charging into each one of the four hearths, where the quantity formed a layer about six inches deep. No stirring or rabbling is necessary. The furnace was heated to about 450 deg. C. prior to charging, when the temperature was gradually raised to about 560 deg. C., maintaining this heat for eight hours. The furnace is cooled for four hours before the charge is withdrawn. By the end of the heat the mass has agglomerated into a sticky mass which must be barred loose. As the manganate is slowly and gradually converted on exposure to air to sodium permanganate, manganese carbonate and manganese dioxide, it must be packed in sealed packages. The crude mass, upon coarse crushing, is more soluble than bleaching powder, and is easier to handle and control. When once dissolved and converted to permanganate by dilution with water, it is comparatively stable.

New Chimney at Tacoma Smelting Company.—The new stack of the Tacoma Smelting Company at Tacoma, Washington, 571 ft. by 23 ft. 11 in., exceeds by one foot the height of the tallest stack previously in existence—the concrete chimney at Saganoseki, Japan. This new chimney was built as a result of the smoke investigations conducted by the American Smelting and Refining Company (see METALLURGICAL AND CHEMICAL ENGINEERING, Vol. XVII, page 682, Dec. 15, 1917), and supplanted a thirteen-year old concrete chimney, 300 ft. by 21 ft. CHARLES E. FOWLER discusses the foundation problems encountered in the construction in *Engineering News-Record*, Vol. 80, page 644 (April 4, 1918). The first foundation excavation was carried about 8 feet below the original surface to a bed of compact sand, but water was encountered in a test pit at a depth of four feet further. Further test pits revealed a strata of hard blue clay lying at from 9 to 30 feet below the first footing. The foundation area was therefore isolated by the construction of long cut-off walls from the surface to this hardpan. As to the foundation itself, three courses were open: First, to risk the uneven settlement on the varying thickness of sand after its drainage; second, to drive concrete piles to the hardpan, or, third, to carry the foundation itself to the hardpan. The third course was adopted, and a reinforced base, as shown in Fig. 1, was designed by R. Bergerson, chief engineer of the Smelting company. The final dimensions of the work are also given in the figure. Throughout the height there is a 4-in. firebrick sectional lining, separated from the shell by a 2-in. air space. A wind velocity of 125 miles an hour, producing a pressure of 78 lb. per sq.ft. in a flat surface was used in the stability calculations. Six-tenths of the projected area of the circular shaft was taken as the effective normal surface. Permissible soil pressure was determined by the formula

$$p = 0.68\ a + 0.014\ ah$$

where a equals 3 tons per square foot for moist sand, of 5 tons of hard clay; h is the depth of the foundation bed in feet, and p is the allowable soil pressure in tons per square foot. The computed maximum base pressure from the assumed wind in combination with the weight of the stack is 5.01 tons per square foot.

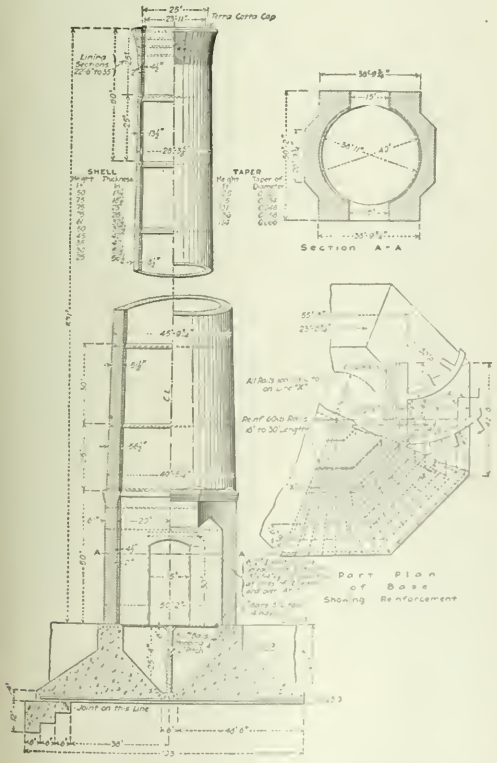


FIG. 1. BASE AND SHELL DETAILS OF TACOMA STACK

Potash from Coal-Burning Blast Furnaces.—Prof. R. A. BERRY and D. N. MCARTHUR present the result of their studies on the question of recovering potash from the coal-burning iron blast furnaces in Scotland, before a joint meeting of the West of Scotland Iron and Steel Institute, and the Society of Chemical Industry. The work is compared with that of Wysor (see METALLURGICAL AND CHEMICAL ENGINEERING, Vol. XVI, page 205, Feb. 15, 1917), and attention called to the fact that the recovery in Scotland is a considerably different problem from that existing in the United States, since the potash content of the ores is not only lower, but coal is used as a fuel in place of coke, which produces a gas heavily laden with tarry matters. Most of the heavy tarry matter is separated in condensers, and in settling carries down considerable dust. The rest of the tarry matter, the ammonia, and most of the remaining fine dust are then caught by the water during the cleaning of the gas in the scrubbers. The spent liquor from the scrubbers, from which the bulk of the tarry matter and the ammonia have been extracted, is usually allowed to waste, although one plant for several years has recovered potassium salts from this by evaporation. On account of the relatively small amount of dust produced, the authors judge the treatment of this liquor to be at present the most likely means of regaining potash. Eight samples of flue dust from coal-fired furnaces were received, containing an average of 8.86 per cent water soluble potash. The total

yearly yield of flue dust from these plants, however, is only 71 tons. These samples of stove dust were analyzed. The yield of this material from coal-fired furnaces is negligible. However, coke-fired furnaces should yield 150 tons of material containing 7.6 per cent of water soluble potash. Samples of tube cleanings from 15 works were received, and while the potash content ranges from only 1 to 2.7 per cent, nearly 15,000 tons of the material is collected yearly. Fifteen works supplied samples of spent liquor which averaged a residue containing 33.5 per cent potash. The authors calculate that 1694 tons of residue could be collected yearly. Owing to the presence of the tarry matter in this liquor, evaporation is retarded, and is a difficult operation, but when the yield of residue amounts to 100 tons per annum, and exhaust steam for evaporation is available, the matter of its recovery is worthy of serious consideration. An evaporating plant would cost about one dollar per gallon daily evaporation; with spare heat the investment would be recovered in a few years, and even if the value of the potash recovered would but pay for the expense, this method would be the best for its disposal. The "pitch" recovered from the gases amounts to about 112 lb. per ton of coal burned, and contains an average of 15 per cent solids, which in turn will analyze 8.8 per cent potash. The burning might be difficult, but probably could be accomplished. A balance computed for one of the co-operating plants showed as follows:

Potash charged into furnace per ton of pig produced		7.6 lb.
Recovered in spent liquor	1.4 lb.	
Recovered in flue and stove dust	0.04	
Recovered in pitch	1.7	
Recovered in tube cleanings	0.2	
Lost in slag	2.7	
Total accounted for	6.04	6.04
Unaccounted for		1.6 lb.

The total quantity of potash recoverable from the potash-bearing by-products from Scottish blast furnaces (12 companies, including 17 works and 102 furnaces) is as follows:

1,694 tons spent liquor residue @ 33.5%	567.4 tons K_2O
100 tons flue dust at 8%	8.0
11,092 tons pitch ash @ 8%	885.8
8,250 tons tube cleaning dust @ 2.5%	206.0
Total possible	1,667.2 tons K_2O

Motor Oils from Lignite.—Investigations recently completed in the *K. W. Institut für Kohlen-forschung*, and mentioned in *Rivista Tecnica d'Elettricita*, Feb. 14, 1918, have shown some remarkable results. Braunkohle and similar lignites were treated with diluted sulphuric acid at ordinary temperatures and a viscous mineral oil of golden-yellow color was obtained, amounting in weight to 5 per cent of the coal. If this oil is treated with naphthaline at higher temperatures, in the presence of chloride of aluminum, an oil is obtained which fulfils the same duties as kerosene. By treating lignites with ozone, carbon compounds are obtained which are soluble in water. It is not possible at this time to judge the true and farreaching chemical importance of these discoveries, says the Italian magazine, which seem to produce fatty substances from lignite.

Carbonization of Illinois Coals.—In Bulletin 20, Co-operative Coal Mining Series, Illinois State Geological Survey, F. K. Ovitz of the U. S. Bureau of Mines gives the results of experiments on the carbonization of Illinois coals in inclined gas retorts. The summary of results and conclusions follows: Illinois coal mixed with Kentucky coal before charging yields better coke than Illinois coal alone. The coke has a more uniform cell structure, is denser, more homogeneous, and stronger. If all the retorts are charged with the same mixture, uniform operating conditions can be maintained to insure proper carbonization of all the charges. If, however, the coals are used unmixed, the charges of Illinois coal require either a higher temperature or a longer period of carbonization than the charges of Kentucky coal. Coke from Illinois coal alone contained more ash and had more tendency to form clinker than coke from a mixture of Illinois coal and Kentucky coal. The Kentucky coal had a low ash content, and the ash had a high softening temperature; consequently the ash content of the coke from the mixture was decreased, and the softening temperature of the ash was raised. The yield of coke from mixtures was larger than from Illinois coal alone, and increased as the percentage of Kentucky coal was increased. The amount of breeze in the coke made from unmixed Illinois coal was greater than in coke from mixtures. The amount of breeze from mixtures decreased as the amount of Kentucky coal in the mixture was increased. Mixtures gave higher gas yields and consequently enabled greater production of gas with a given equipment than could be obtained from Illinois coal alone. There is a considerable supply of Illinois coal with a sulphur content low enough to permit its use for gas making without operating trouble from sulphur. The more general use of Illinois coal in gas plants deserves careful consideration from gas manufacturers. At many plants in the Central West the cost of producing the gas can be considerably reduced by using either Illinois coal alone or by mixing with it another coal.

Alternating Current Electrolysis.—Experiments on this subject are described in the *Journal of Physical Chemistry*, for February, 1918, by Harry B. Weiser. The results of the investigation are summarized by the author as follows:

The efficiency of the electrolytic corrosion of solid metallic electrodes with the alternating current varies so widely with minor differences in the electrode surface that the results of a given set of experiments cannot be reproduced.

The mercury electrode in thiosulphate solution under the influence of the 60 cycle alternating current is reproducible.

The effect of widely varying conditions on the efficiency of electrolytic corrosion with the alternating current of constant frequency has been studied with mercury electrodes in sodium thiosulphate solution.

The efficiency of corrosion increases almost directly as the concentration of thiosulphate solution. With too high a concentration, however, a film of sulphide forms over the electrode which cuts down the corrosion.

The efficiency of corrosion increases with the current density but not in direct proportion. The variation from strict proportionality is greater in dilute than in concentrated solution.

Mechanical stirring increases the efficiency of corrosion.

The efficiency of corrosion decreases with decrease in temperature.

Any variation in conditions that affects the concentration of electrolyte in the immediate region of the electrodes correspondingly affects the efficiency of corrosion.

Under like conditions zinc electrodes corrode much less readily with the alternating current than do mercury electrodes.

The effect on the efficiency produced by variations in current density, stirring, temperature and concentration of thiosulphate solution is of the same character with solid metallic electrodes as with mercury; but with the former these effects are negligibly small compared with that resulting from slight differences in the electrode surface.

Recent Metallurgical and Chemical Patents

Zinc and Lead

Details of the Electrolytic Zinc Process.—A series of patents have been issued to FREDERICK LAIST and J. O. ELTON of Anaconda, Mont., (assigned to the Anaconda Copper Mining Co.) on certain features of the electrolytic production of zinc.

In order to clear the electrolyte of arsenic and antimony the precipitation of an excess of ferric hydroxide by lime or otherwise is necessary. This carries down nearly all of these elements, probably as ferric arsenate and antimonate. More iron may be required than is dissolved from the leached ore, and while this deficiency may be gained by passing the solution over iron-bearing material, this method is very slow, and the inventors prefer to supply it as follows: Scrap iron or iron ore is heated with 20 per cent sulphuric acid until the solution contains 5 per cent or more iron, when manganese dioxide or any oxidized ore of manganese is added to the hot acid solution, quickly bringing all iron to the ferric condition. A sufficient quantity of this ferric solution is then added to each leach, the iron, with the arsenic and antimony, is precipitated and removed. The manganous salts may be reoxidized in the electrolytic operation and are available for re-use. (1,255,436, Feb. 5, 1918.)

Instead of adding the ferric precipitate (containing a very material quantity of zinc sulphite) to the unroasted ore and subjecting it to a high temperature calcination which not only oxidizes the iron to an insoluble state, which is desirable, but also destroys any sulphates present with the accompanying waste of sulphuric acid, the latter may be avoided by roasting the precipitate in a separate furnace with temperature controlled and less than 625 deg. C. (1,255,438, Feb. 5, 1918.)

Or this precipitate and all other residues containing all the copper, lead, silver, gold and also a material percentage of the zinc of the original ore may be dried, mixed with fine coal, and smelted in a reverberatory furnace. There will result a matte containing most of the copper, silver and gold, a fume consisting principally of oxide of lead and zinc, and a slag which is reasonably free of values. The fume is collected in a bag house or otherwise, and is returned to the leaching plant where it is treated with dilute sulphuric acid. The zinc sulphate solution produced is treated as other like solutions, and the residue containing most of the lead of the original ore may be dried and smelted

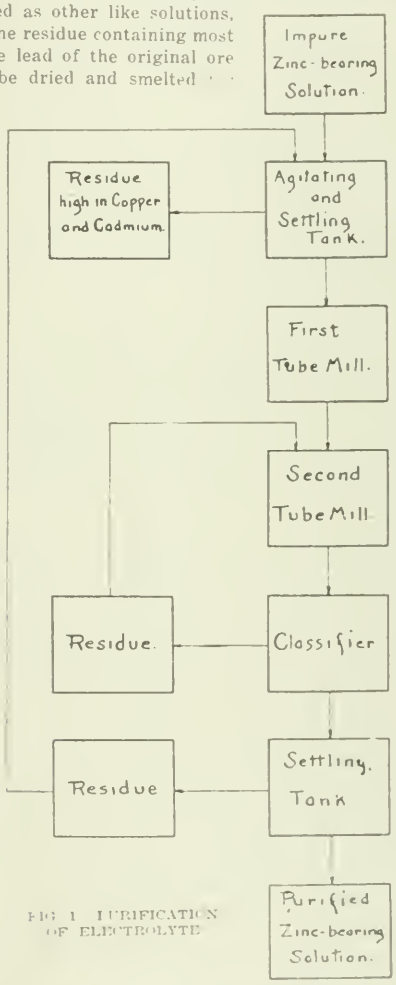


FIG. 1. PURIFICATION OF ELECTROLYTE

lead in the usual manner. (1,255,440, Feb. 5, 1918.)

Since the precipitation of impurities in the electrolyte ordinarily requires a large excess of zinc, while tube mills with zinc balls necessitate a very slow rate of flow, the inventors patent the process shown in the flow sheet, Fig. 1, wherein the bulk of the copper, cadmium and other electro-negative metals are first precipitated by zinc dust. The clear solution then goes to a pair of tube mills, the first with zinc balls, the second with zinc shot. Thus the purification is effected at a higher rater of speed. (1,255,434, Feb. 5, 1918.)

They further patent another method of purifying solutions of traces of copper and cadmium by the use

of zinc sponge which is more efficient than furnace metal. This sponge is prepared by the electrolytic precipitation from the cold, neutralized, impure solution itself at voltages between 0.5 and 2.3, and current densities between 2 and 30 amp. per sq.cm. Zinc anodes are used, maintaining normal concentrations of the metal. At lower voltages the sponge tends to collect on the bottom of the cell, but it may effectively remain suspended in the solution or attached to the cathode. If the rate of flow of the solution is slow its complete purification may be effected during the passage and the sponge may be available for other portions. A more rapid rate is desirable, so that the overflow carries sufficient sponge to complete its own purification. If the current conditions are properly regulated, little or no zinc is precipiated, the deposit consisting of the more electro-negative impurities. If care is taken to dry the sponge under strictly non-oxidizing conditions it may be used in place of the ordinary zinc dust at a later time. (1,255,435, Feb. 5, 1918.)

The formation of the zinc sponge may advantageously follow a primary purification by metallic zinc, when residual traces of arsenic are eliminated as arsine. For deposition of the purified solution into coherent cathodes, the conditions should preferably be: acidity of 4.5 per cent, temperature of 35 deg. C., voltage from 3 to 4, current density 0.0215 to 0.0323 amperes per square centimeter. (1,255,439, Feb. 5, 1918.)

Difficulty in making a coherent deposit depends not only upon the purity of the electrolyte, but upon the cathode as well, which must be highly electro-positive. Thus, pure aluminium is quite suitable, but aluminium containing 5 per cent of copper will often take no deposit, while 1 to 2 per cent copper will scarcely deposit after it has been stripped a few times. Aluminium bronze may be made to take a good deposit if the alloying metals be removed by nitric acid, and the resulting film of alumina removed. After a few deposits, however, when the pure aluminium surface thus prepared becomes contaminated or worn, a retreatment is necessary. The more electro-negative impurities in the cathode sheet are thought to form couples with the deposited zinc, greatly increasing the rate of solution and therefore cutting down the current efficiency. Laist & Elton therefore patent the use of a pure electro-positive cathode. (1,255,433, Feb. 5, 1918.)

Since the ill effects of a small impurity on the electrodeposition persist for days after the inflowing solution is restored to normal, the inventors equip a test cell with electrodes similar to those employed in the main system, and so place this cell as to receive a continuous portion of the purified solution passing to the storage tanks from which the main electrolytic cells receive their supply. The current and other conditions in this indicator cell being maintained as in the main cells, the quality of the deposit and the current efficiency serve as an accurate indication of the purity of the electrolyte. In case any portion of the solution falls below the standard of purity, this part can be re-purified before entering the main cell room. (1,255,437, Feb. 5, 1918.)

Treatment of Zinc-Lead Fume.—C. C. NITCHIE, of Depue, Ill. (assigned to the New Jersey Zinc Co.), proposes the mixing of zinc-lead fume with sufficient ammonium sulphate to transform all other metallic compounds contained into the corresponding sulphates. The reactions are of the following type:

$$ZnO \times (NH_4)_2SO_4 = ZnSO_4 \times 2NH_3 + H_2O$$

The mixture is heated in a suitable muffle; the reaction commences at about 225 deg. C, and proceeds rapidly at 300 to 350 deg. The escaping ammonia is recovered for reuse. After the reaction the temperature is raised to about 625 deg. C, to expel arsenic and to render iron sulphates insoluble. Water leaching will now produce a residue containing most of the lead, silver, gold, iron, and silica and but little copper and zinc, and can be easily smelted in a lead blast furnace. The solution contains most of the copper and zinc, and but little of the other impurities. It can be purified and electrolysed; or it may be evaporated and the lead-free salt retorted in the usual way. Or finally, it may be precipitated as a basic compound by the addition of ammonium carbonate, with the formation of the corresponding amount of ammonium sulphate for reuse in the early part of the process. (1,258,934, March 12, 1918.)

Zinc Chloride from Zinc-bearing Ores.—FRANK K. CAMERON and others of Salt Lake City, Utah (assigned to American Smelting and Refining Company), patent the process of mixing an oxidized or roasted complex ore with a slight excess of 30 per cent HCl, heating the mixture slowly at first to drive off CO_2 and other gases, then quickly to complete dessication, and finally for a sufficient time at about 300 deg. C. to complete the evolution of acid gas. Thus iron, manganese, aluminium, silicon and magnesium are converted into insoluble oxides, and after lixiviation the solution will carry practically all of the zinc as chloride. It also contains calcium and lead chlorides, which are removed by precipitation with zinc sulphate. Iron and aluminium may be removed by known methods, or the solution purified as noted in the following patent. (1,261,695, April 2, 1918.) As an alternate process, the ore, pulverized to 100 mesh, is mixed dry with sodium or calcium chloride containing sufficient chlorine to combine with the metallic bases. Distillation in an iron retort will volatilize lead, silver and gold chlorides, and transform the zinc into a basic chloride which is retained in the residue. The residue is then leached in hot water acidified with HCl. In case there is much separation of gelatinous silica, evaporation to dryness may be necessary, followed by an additional leaching. The zinc chloride may be precipitated as a solid halide of sodium, potassium or ammonium by adding the desired alkali chloride to the solution. This salt may be further purified by recrystallization, and may be then decomposed with strong hydrochloric acid. (1,261,696, April 2, 1918.)

Production of a Superior Zinc-Lead Pigment.—J. A. SINGMASTER and F. G. BREYER of Palmerton, Pa., (assigned to New Jersey Zinc Co.) have ascertained by an examination of various fractions produced in the process of zinc-burning, that those fractions having a good body or oil absorbing capacity and hiding

power, and which were not overheated, showed a higher ratio of sulphur to lead than similar pigments of a pronounced pink tint. Overheating the pigment substitutes a yellowish tint for the pink, and furthermore granulates the fume. They therefore patent the process and method of burning a zinc-bearing substance in a pigment furnace—such as the blast-furnace type or of the Wetherill grate-furnace type—volatilizing the zinc and lead from the charge, immediately oxidizing the same in a sulphatizing atmosphere, and quickly removing the fume from the region of high temperature. The sulphatizing atmosphere may be obtained by mixing a sufficient quantity of sulphur bearing ores with the oxide, by interrupting the preliminary roasting operation at that point where sufficient sulphur will remain in the calcine, by adding elemental sulphur, or by dropping sulphuric acid into the furnace. The ratio of sulphur to lead oxide necessary to make the improved pigment may lie between one-half and four-thirds, but preferably is about five-sixths. In any case, it is important that the sulphatizing compounds be of such a nature, and be added in such a way that they will furnish the required amount of sulphate throughout the entire evolution of the metal. (1,257,136, Feb. 19, 1918.)

Recovering Zinc from Slags.—HERMAN WITTEBORG of Caldwell, Idaho, patents the arrangement of recovering zinc from slags as follows: He causes the slag to flow through a succession of long, narrow, reverberatory furnaces in a thin sheet, where it is superheated by an oxidizing flame, and possibly stirred by a hot air blast. Lime to substitute as a base, and carbon for reduction purposes, may be added to the slag at the outset. The resulting furnace gases are collected and the metallic oxides condensed and separated. (1,250,261, Dec. 18, 1917.)

Removing Cadmium from Zinc Ores.—CHARLES P. FISKE, of Palmerton, Pa., (assigned to New Jersey Zinc Co.) patents the application of an ordinary Brückner furnace to the method of eliminating cadmium from zinc calcines already covered in Patent No. 1,161,885 (see METALLURGICAL AND CHEMICAL ENGINEERING, Vol. XIV, page 220, Feb. 15, 1916). This process consists of heating the calcine in a reducing atmosphere at temperatures ranging from 700 to 850 deg. C., wherein the cadmium is eliminated. In the later invention the reducing atmosphere is maintained by the admission of producer gas into the fire-box opposite the flue connecting to the roasting cylinder. (1,246,576, Nov. 13, 1917.)

Composition for Retorts.—J. D. HOLLINGSWORTH and JOHN MITCHEM of Kusa, Oklahoma, have discovered that zinc retorts of the following composition have a life of up to sixty days when working on Western ores, as compared to twenty days if made of the ordinary mixtures. They dry-mix 36 lb. of St. Louis fire clay with 59 lb. of fire clay cement (hard burned clay ground to a powder) and 14 lb. of "cc" or "g" grade graphite, and then pug this mixture with a solution containing 25 per cent by weight of common salt. The resulting dough is allowed to stand for 24 hr., then molded to shape in a hydraulic press, and dry-heated at approximately 120 deg. F. for from 15 to 20 days. The dried retort is gradually preheated before use. (1,249,960, Dec. 11, 1917.)

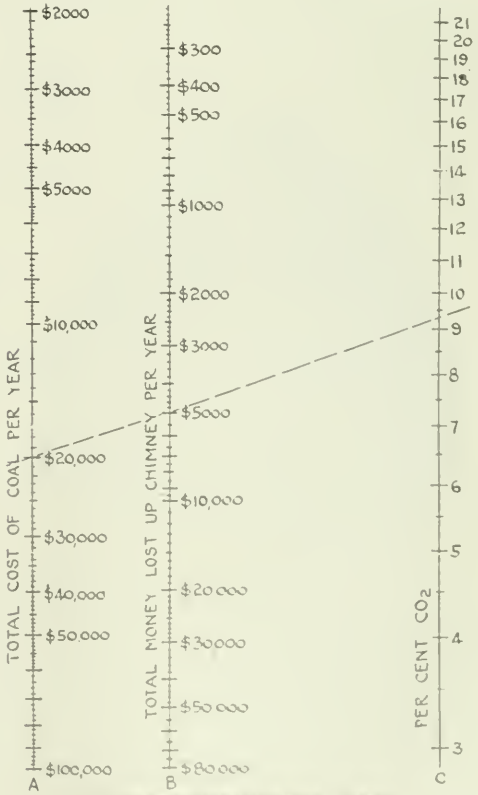
Determining Loss Due to Low Carbon Dioxide

THE accompanying useful chart has been developed by the Uehling Instrument Co., 71 Broadway, New York. It is of unusual interest and value at the present time when the coal problem is so important, for it enables anyone to quickly and closely estimate the money now being lost up almost any chimney due to low CO_2.

Simply connect the percentage of CO_2 (shown in column C) with the money now being spent per year for coal, (shown in column A) and the intersection of the connecting line with column B immediately gives the amount using from the chimney in the form of heated gases.

The object of this chart is to show that a high percentage of CO_2 is most desirable. Even where the CO_2 is as high as 21 per cent, the theoretical maximum there is a loss because in the average power plant the flue gases leaving the boiler have a temperature as high as 500 or 600° F. Loss therefore is inevitable unless a blower is used for exhausting the gases and some sort of interchange system is installed for either heating the feed water or preheating air and leading it under the grate.

It is significant that most of the large power plants



of today have adopted CO_2 instruments that record automatically and continuously. The reason for this is to keep constant tab on the workers in the boiler room and the efficiency of combustion. The recorder may be placed at any convenient distance from the boiler in the office of the chief engineer, owner, manager or superintendent, while an auxiliary CO_2 indicator is placed on the boiler front in full view of the fireman. The function of the indicator is to keep the fireman constantly informed as to the efficiency of his own work. This feature is most commendable.

Coal cannot be saved by a CO_2 machine alone. If no attention is paid to the indicator or recorder, the installation of such apparatus is useless. The records should be carefully watched and studied and adjustments should constantly be made in firing methods until the best percentage of CO_2 is obtained. After the best mark is reached, fluctuation of the CO_2 line below that mark to any great extent should not be allowed.

This chart is based on a flue gas temperature of 600 degrees F., and an outside air temperature of 60 degrees F. Where the flue gas temperature is higher, or the outside air temperature lower, the money loss will be correspondingly increased. On the other hand, with a higher outside air temperature and a lower flue gas temperature, the money loss is proportionatly decreased. Further, in the construction of this chart, it has been assumed that the coal has a calorific value of 14,500 B.t.u. per lb. of combustible.

It may also be interesting to point out that where there is only 3 per cent of CO_2 in the flue gases, 76 per cent of the heat value of the coal passes up the chimney as waste under the conditions outlined above. It is impossible, however, for these gases to contain as low as 2 per cent, because it would require more than the original quantity of heat in the coal to heat the enormous surplus of air to a temperature of 600 degrees F.

A New Pressure Governor for Gas and Liquid Systems.

IN MANY power installations, where air, other gases or liquids must be maintained under pressure, the demand for an automatic method of doing this has arisen.

As a result the General Electric Company has developed a new pressure governor to control standard self-starters for motor operated pumps and compressors. The governor maintains a pressure between predetermined limits on any gas or liquid systems that will not corrode the Bourdon Tube.

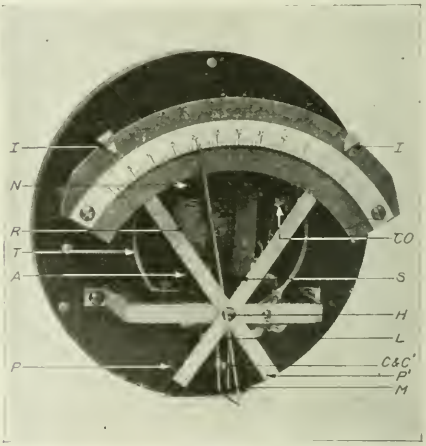
The governor can be used on any standard a.c. or d.c. circuit. It is rated for pressures of 80, 100, 160, 300 or 500 lb. and operates within settings of from 3 to 12 lb. between high and low pressures. Governors for higher pressure are also made.

The governor shown in the accompanying illustration consists of a Bourdon Tube, an indicating needle, a graduated pressure scale, adjustable high and low pressure stops to determine the desired pressure range and a relay which actuates the contacts in the control circuit of the self-starter, all enclosed within a dust proof case, easily opened for inspection.

Action of the governor is dependent on the Bourdon Tube which should be connected to an independent discharge pipe from the pressure tank. The free end of the tube T is mechanically connected to the indicator needle N moving it over the scale as changes of pressure affect the tube.

After the settings for the pressure range have been made, the governor will automatically maintain pressure within those limits. The operation of the pressure governor is as follows:

Assuming that the pressure is at the low value, as indicated by the left-hand indicator I, the contact C on the needle N completes the circuit through the contact C′ on the movable arm M, which at the low pressure points rests against the stop P′. When this contact is



THE INTERNAL MECHANISM FOR A CR 2922 PRESSURE GOVERNOR

made, the circuit is completed through the relay coil R, causing the armature A to close. Attached to this is the contact CO which upon closing, completes the control circuit to the self-starter, causing the motor to start.

The armature is also attached to the spring S which holds the contact C′ firmly against C until contact is broken at P.

As the pressure increases, the needle pointer moves to the right, but its lower part to which the contact C is attached moves to the left, and is followed by the movable arm M. When the high pressure point is reached, the movable arm is prevented from traveling further by stop P and the needle continues its course, breaking the circuit by separating contacts C and C′. The instant the circuit is broken, the relay R is de-energized, its armature falls, releasing the tension of the spring S and because the movable arm M is counterweighted it returns to the stop post P′.

When the pressure is decreased to the minimum value, the contact C again completes the relay coil circuit by engaging contact C′ and the cycle of operation is repeated.

The case is tapped and drilled at the bottom for the pressure pipe and electrical conduit connections.

An Automatic Acid Elevator

AN AUTOMATIC device employing air pressure for blowing acids to higher levels has been developed by the Monarch Manufacturing Works, of Phila., Pa. A patent on the device has been applied for. Fig. 1 is a diagram of the device connected to an acid egg, and Fig. 2 shows the interior construction.

The liquid (acid) flows from low-level tank through the combination check valve and air device into the blow-case. An exhaust check valve EC is placed in the exhaust line, through which air displaced by the in-flowing acid escapes. This exhaust line may be carried back to the filling tank or elsewhere. As the blow-case becomes full of acid, the surging effect created under-

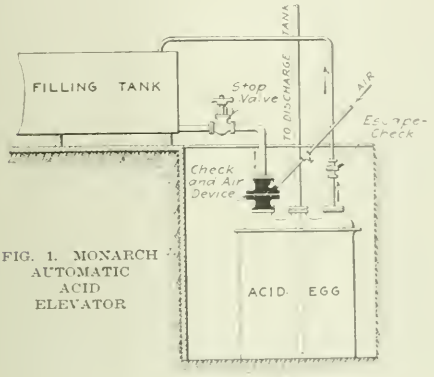


FIG. 1. MONARCH AUTOMATIC ACID ELEVATOR

neath the air valve within the air device proper tends to unseat the air valve (plug), thus allowing compressed air to escape from ports C.A.P. (Fig. 2). This air being under high pressure kicks the air valve up against the under side of the inverted cup-shaped check, carrying both up until the top of the liquid check engages with seat S, thus preventing inflow of liquid or escape of compressed air back to the filling tank. The pressure of the air then acts on top of the liquid within the blow-case, forcing it out the discharge pipe, which as usual, is carried almost to the bottom of the case.

When all the acid has been discharged, there is a sudden rush of air through the discharge pipe, which relieves the pressure within the case, because the area of the air ports C.A.P. is very much smaller than the area of the discharge pipe. The pressure of the air within the blow-case having dropped to practically nothing, allows the air valve and liquid check to fall back into position, the former shutting off the air ports and the latter permitting the re-filling of the blow-case.

The exhaust air check valve EC allows air under low-pressure (exhaust air displaced by the inflowing liquid) to pass, but when the blow-case is filled, a column of liquid rises in the pipe underneath the check EC, and when air pressure is turned on through operation of the automatic air device proper this column of liquid, under pressure, forces the exhaust air check shut, in which position it remains until the blow-case has been emptied and pressure relieved therefrom, as previously explained, when it again opens for escape of displaced air.

By use of this automatic device compressed air is saved to a considerable extent, for the reason that the air is turned off almost instantly the blow-case is emptied, whereas in the hand operated blow-cases, the attendant of course cannot know exactly when the case

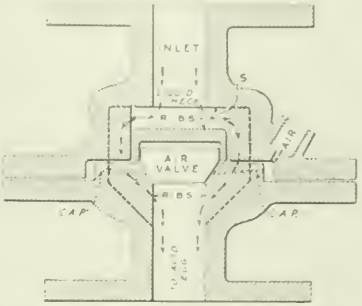


FIG. 2. AUTOMATIC ACID VALVE

is empty, and usually his attention is required by another case or elsewhere, so that it would not be possible for him to turn off the air even though he could know exactly when the case was empty.

New Lamp Screen for Industrial Lighting

A new article for improving industrial lighting has been placed upon the market by the Laco-Philips Co., 131 Hudson St., New York. It is called laco-dalite and consists of a special blue-glass screen that is clamped

FIG. 1. SCREEN AND COVERING FOR INDUSTRIAL LIGHTING

over the bottom of the electric light reflector, thus inclosing the bulb. The light thus filtered through the special blue glass, it is claimed by the manufacturers, is equal to that obtained from the nitrogen lamp. It is white and pure and the equivalent of daylight. The question of proper lighting is important in concentrators, especially for table work at night. Both here and in the draughting room as well as in other places a device of this sort should prove helpful.

Book Reviews

MODERN INORGANIC CHEMISTRY. By *J. W. Mellor*, D. Sc. New edition, crown 8 vo. (13 x 19 cm.), 903 pages, 334 Illustrations. Price $2.50, 7/6. New York and London: Longmans, Green and Co.

The author is well-known for his books on chemical statics and dynamics, and higher mathematics for students of chemistry and physics. In this hand-book for students, and chemists in general, he discusses all the varied phenomena of chemistry, from the simplest to some of the most complex, and after presentation of the facts he draws the evident, or probable, or possible, conclusions as to the theoretical explanation—the *why* and the *wherefore*. Working through this book must be a great exercise in chemical philosophy to the student—a training of his wits, a systematic strengthening of his reasoning powers, an introduction to a higher level of chemical understanding. It cannot but whet the student's appetite for more, and inspire him to higher chemical ambitions. All this can be done by a chemical textbook—when it is written skilfully by a master chemist.

* * *

COAL GAS RESIDUALS. By *Frederick H. Wagner*. 244 pages, illustrated with working diagrams. Price $2.50. New York: McGraw-Hill Book Company, Inc.

In view of the great importance of the by-products of coal to modern industry, especially in its present belligerent phase, it is remarkable that so few books have been written on the subject. One of the few is the volume entitled "Coal Gas Residuals" by Frederick H. Wagner, a second edition of which has recently been issued. This new edition is in many respects a considerable improvement over the first. Information bearing on the uses of the various products in the war has been added that will interest the gas-plant operator who desires a rapid and non-technical summary showing the ultimate useful products derived from the raw materials which he is engaged in producing. The additions include a description of the manufacture of nitric acid from ammonia which has been so important to the German military machine, and a rather hurried resumé of the more important coal tar derivatives and the processes by which they are made. The author has hardly gone far enough in emphasizing the absolute necessity of such products as ammonia, nitric acid, ammonium nitrate, phenol, picric acid, aniline, toluene and trinitrotoluene to a nation at war. In view of the importance that the author attaches to spent oxide as a raw material for sulphuric acid, the chapter on this subject is disappointing because it consists merely in a brief description of the well known processes without even mentioning the peculiar disadvantages of spent oxide and the means that may be employed for overcoming them.

The technical interest and the popular value of the book would be much enhanced if the author had dealt with the important subjects of gas treatment, tar extraction and ammonia recovery from an impartial standpoint instead of being so obviously biased by the theories of the late Dr. Walther Feld. Of many of the Feld ideas, particularly the celebrated series of differential washers so beautifully ideal or ideally beautiful on paper, and so utterly impossible in practice—it may be deeply regretted here in America that they were not at once seized upon and universally adopted *in Germany*, for thereby the downfall of the Kaiser would have been materially accelerated. "As no tar separating plants of the Feld system have as yet been erected in the United States, statements showing results obtained in this branch of by-product recovery will necessarily have to be confined to European practice." The unconsciously pathetic retention of this sentence in the second edition tells its own story. However, frank exploitation does less harm than disguised partiality and Mr. Wagner may be admired for the constancy of his rather lonesome discipleship.

The principal value of the book will be to those who desire a description of the various by-products of coal and the methods and apparatus used in handling them without too many technical details. The descriptions are well written and usually carefully illustrated. The appendix contains a number of tables which the gas engineer and chemist will appreciate, particularly a table of constants for certain gases and vapors. The engineer who desires to obtain a general knowledge of the various systems of ammonia-recovery practiced in Europe will be attracted to the chapter on ammonia, although American practice has contradicted many of the comparative statements given. The Koppers system of benzol recovery and purification is discussed in interesting detail following the outlines of Puening's description.

Personal

At the Annual Meeting of the Chemists Club of New York the following officers were elected to serve for the following year: President, Ellwood Hendrick; vice-president, Charles H. Herty; non-resident vice-president, Charles L. Parsons; secretary, John R. MacPherson Klotz; treasurer, Henry M. Toch; two trustees to serve for three years, Thomas R. Dunning and Kenneth C. McKenzie.

Mr. C. G. Atwater, manager of the agricultural department of the Barrett Co., has taken up active duties with the Ordnance Department as consulting engineer in connection with the government nitrate plant.

Mr. H. Foster Bain has been appointed assistant director of the U. S. Bureau of Mines and is in the office of the bureau at Washington.

Mr. D. J. Coffey, formerly of the Schumacher Mill at Porcupine, has been promoted from mill superintendent to general manager of the Lake Shore properties, situated near Cobalt, Ontario, succeeding John W. Morrison.

Mr. Fred B. Crosby has resigned his position in the power and mining department of the General Electric Co., Schenectady, N. Y., to become electrical engineer of the Morgan Construction Co., Worcester, Mass. Mr. Crosby has specialized in electrical equipment for steel works.

Mr. John M. Eckert, assistant engineer in the gas and oils department of Underwriters' Laboratories, has entered the Ordnance Department, U. S. A., as supervisor of Tests at steel plants in the vicinity of Chicago and also in Ohio, Indiana, Wisconsin and adjoining states. Physical tests, chemical analysis, heat treatment at plants and the instruction of inspectors for this territory will come under Mr. Eckert's direction.

Dr. Rudolph Gahl has resigned from the position of metallurgist, in charge of concentrator, at the Inspiration Consolidated Copper Co., Miami, Arizona, to devote his time to consultation practice. Guy H. Ruggles, formerly mill superintendent for the Humboldt plant of the Consolidated Arizona Smelting plant will succeed Dr. Gahl.

Mr. N. J. Gebert, director of the metallurgical laboratory, Standard Roller Bearing Division of Marlin-Rockwell Corporation, has resigned his position and joined the staff of Mr. Herman A. Holz, New York. Mr. Gebert will be in charge of the metallurgical and magnetic laboratory which Mr. Holz is equipping in the Metropolitan Tower, New York City.

Mr. Justice Grugan has discontinued his mining engineering office at 30 Church Street, to assume the duties of chief engineer for Suffern Company, 135 Broadway, New York.

Mr. E. H. Hamilton, formerly metallurgical manager of the Trail Smelter of the Consolidated Mining and Smelting Company of Canada, has been made smelter superintendent of the Midvale, Utah, plant of the United States Smelting Company to succeed Mr. L. D. Anderson, who was appointed manager of the same plant some time since.

Dr. A. W. Homberger, head of the chemistry department of Wesleyan University, leaves this college after the end of the Spring work and goes to the University of Louisville, Kentucky, to be dean of the chemistry department at that place. Dr. Homberger has been at Wesleyan for seven years.

Mr. ARTHUR HOUGH, consulting chemical and explosives engineer, has joined the staff of the Durion Castings Company in a consulting capacity. Mr. Hough for a number of years past has been engaged in the manufacture of acids and explosives of a general character, and has devoted a great deal of time to the development of products such as trinitro toluol, trinitro benzol, and ethylene glycol for the preparation of dinitro glycol, chlorhydrin for the preparation of mustard gas and monochlor benzol.

Mr. M. T. LOTHROP has been appointed assistant factory manager of the Timken Roller Bearing Company of Canton, Ohio. For the past seven years he has been metallurgist for the company and has also been in charge of the steel and tube departments.

Mr. R. B. MOORE, in charge of the Golden, Colorado, station of the Bureau of Mines, has been visiting Eastern cities in connection with Government business.

Mr. JACQUES S. NEGRU, mining engineer of Denver, Colorado, has enlisted with the Canadian forces and has gone to Winnipeg to be detailed to the Engineers Corps. on Railway work.

Mr. W. C. POTTER, formerly with the A. S. & R. Co., in Mexico, has been appointed head of the Equipment Division of the Signal Corps in charge of production of airplanes and motors for the army.

Mr. J. M. RIORDAN, until recently sales engineer of the Grant Lees Gear Company of Cleveland and formerly representing the Fellows Gear Shaper Company of Springfield, Vermont, in the Central States, is now connected with the sales organization of the Cleveland Milling Machine Company, 18511 Euclid Avenue, Cleveland, Ohio.

Mr. ALBERT TATE SMITH, lately manager of the R. U. V. Company, 50 Broad Street, New York City, has returned to the Permutit Company, with which he was formerly connected, to take the position of assistant manager of sales.

Mr. WILLIAM W. TORRENCE, formerly of the General Electric Company, has been appointed general manager of the Denver Engineering Works Company, succeeding Mr. Lewis Searing, who has resigned.

Mr. H. G. WEIDENTHAL, formerly works manager of the General Steel Company, Milwaukee, Wis., has joined the forces of James H. Herron, Cleveland, Ohio, in the department of steel works design and operation. Mr. Weidenthal will give special attention to electric steel making furnace operation.

Mr. FRED D. WILLIAMS, head of the power specialties department of the H. W. Johns-Manville Co., severed his connection with that company and went to the L. H. Gilmer Co., on April 29, as assistant general manager of the combined properties of that corporation, with headquarters at Tacony, Philadelphia.

Mr. WM. WRAITH, of the International Smelting Co., has been elected president of the Utah Section of the American Institute of Mining Engineers, Walter Fitch of the Chief Consolidated Mining Company vice-president, and F. G. Moses, of the Utah Station of the U. S. Bureau of Mines secretary, at the annual meeting held in Salt Lake City recently.

Current Market Reports

Non-Ferrous Metal Market

Wednesday, May 8.—There is nothing much to report on lead or spelter. The price of tin has advanced.

Copper.—The British government is now making big demands on the producers, who anticipate difficulty in meeting the requirements for copper in May. The copper producers have been in session with the price-fixing committee of the War Industries Board.

Tin.—The London tin market jumped £20 per ton and our market has become unsettled for any business until buyers can see more clearly the reason for this advance. The price in London is £360. Spot tin, Straits tin or Standard tin is not available.

Lead.—The lead position remains quiet and without special feature. The Trust price is 7c. per pound with independents quoting slightly above.

Spelter.—The spelter market continues dull. A little more business is recorded and prices are quoted around 7c. per pound.

Antimony.—A little more business is reported during the past week. The spot market price for antimony regulus is 13c. per pound, with shipments from the Far East quoted at 12½c., duty paid.

Tungsten.—A fair volume of business was done. The prices remain unchanged at $24.00 for high-grade wolframite and $24.50 for high-grade scheelite, although the latter is not so much in demand for immediate delivery as it is for future delivery. In view of the high freight and expense of shipping, the foreign shippers see, if possible, that no material under 60 per cent is shipped to this country.

Manganese.—The Government is contemplating the enactment of regulations whereby a maximum price will be established for domestic manganese ore. Shortage of high-grade ore becomes more and more acute and an increase in schedule price is expected.

Chrome.—Unchanged at $1.50 per unit for 45 per cent grade. Owing to the shipping situation, shipments of foreign chrome ore have virtually ceased. The few thousand tons that happen to be afloat and unsold have fetched as high as $100 per ton. The market for domestic ore is still chaotic, as it has been during the last year.

OTHER METALS

Aluminum, lb., 98-99 per cent., virgin, Government price	32
Bismuth, lb	2 50 2 75
Cadmium, lb	1 40
Nickel, electrolytic, lb	40
Silver, oz	1 00
Platinum, oz	108 00
Palladium, oz	150 00
Cobalt, lb	3 25 3.50
Magnesium, lb	2 00
Quicksilver, Cal	125 0
Quicksilver, Mexican	118 00

The Iron and Steel Market

Steel manufacturers have been revising their rolling and shipping schedules to conform to the new requirements of the Washington authorities. The revision, which has been in progress for several weeks, is along two lines: (1) For the diversion of the maximum possible tonnage to government orders, known as classes I and II and representing war material required by the Government and by its allies; (2) A distribution of the remaining steel to the lines of consumption where it will do most good in helping to win the war.

As to the diversion of more steel to direct war orders, an impetus was given to the changes already in progress by the developments at the meeting held in New York, April 26, between J. Leonard Replogle, Director of Steel Supplies under the War Industries Board, and about fifty representative manufacturers. The meeting was held in the office of President Gary of the American Iron and Steel Institute, and the president submitted a pledge, afterwards circulated to all producers, that they should make a maximum effort to furnish all possible steel for the government requirements. The situation was that the War Industries Board had considered the taking over of all steel shipments, and had indeed drawn up an order to that effect, but by reason of the understanding reached at the meeting Mr. Replogle undertook to see that the order was held in abeyance. The War Industries Board does not desire to take over the distribution of the so-called "commercial" steel unless such action proves necessary, and much prefers that the steel producers make the distribution of steel themselves. In this distribution it will furnish all the aid and advice possible. The board has already made known that among the commercial uses, coming after direct government orders, the highest classifications should be steel for the development of oil production and the transport of oil, and steel required in agricultural pursuits. This decision helps the steel trade considerably but makes only a beginning in the allotment to the number of gradations from

the most essential to the least essential lines of steel consumption. Of sacrifices for the war there is no end, and one sacrifice is that of diction, since in normal times the word "essential" is hardly used in the comparative degree.

War Steel Requirements

The shipbuilding operation calls for much more steel than was estimated by producers, even quite recently. In the first place, vessel completions have been steadily increasing, being in the first fortnight of May at the rate of more than 4,000,000 tons deadweight per annum, representing at least 2,000,000 gross tons of steel. In the second place, vessel launchings are at a greater rate than vessel completions. In the third place, keels laid are at a greater rate than launchings, as they represent prospective completions of several months hence. Finally, it is desired to accumulate fabricated parts at shipyards and steel for fabricating at the various fabricating plants, both for the purpose of facilitating the current work and for the purpose of accumulating a reserve against contingencies, including the possibility of traffic difficulties next winter.

Shell steel requirements have been increasing rapidly, as forging capacity has been increased. The forging capacity has been quite below the capacity of the shell making factories, but the shortage has now been eliminated entirely, except as to shells 6-inch and larger, and that situation is expected shortly to be righted.

Structural requirements have been increasing, and there is even a statement that the government requirements in fitted structural work exceed by 20 per cent the average amount of fabricating work done in the past three years, for commercial purposes.

Orders for approximately 100,000 freight cars have been placed, involving more than 1,000,000 gross tons of steel, including plates, shapes, bars, wheels, etc. The cars are to be built according to the original plans, involving substantially the usual employment of steel, except that the inside roof is used on box cars, involving about 400 pounds per car of galvanized sheets, instead of the more modern all-steel construction involving more than double as much. The War Industries Board requires, however, that the Railroad Administration accept Bessemer steel in plates, etc., when it is more convenient for the mills to furnish Bessemer than open-hearth.

Bessemer steel is also to be used for rails, in all probability. Reports from Washington relating to prospective "orders" for Bessemer rails are somewhat misleading. The railroads have a large tonnage of rails now on order at the mills. There will be only very limited tonnages ordered afresh, but it will probably be required that on many of the orders on books, originally entered for open-hearth steel, Bessemer will be required instead. On account of the two $5 a ton advances that occurred in 1916, and the long delays in filling old orders, the orders now on books are for Bessemer rails at $28, $33 and $38 and for open-hearth rails at $30, $35 and $40.

Commercial Market Remains

Reports that there is no commercial market for steel are an exaggeration, for effect. The large mills as a rule are adhering to former practice and as shipments are made to regular commercial customers they enter additional tonnages for them, but with absolutely no promise, or even intimation, as to the probable time of delivery. Shipments on old orders are to be made, as already indicated, in accordance with the availability of steel, after direct government orders are taken care of, in accordance with the degree of importance of the item of steel consumption involved.

There is, of course, a great deal of steel left while mills are taking care of government orders to the fullest extent possible. Such remaining steel falls into four classes: (1) Rejected ingots under government specifications; (2) crops required to be taken under government specifications; (3) Bessemer steel left after the relatively small proportion is furnished that is acceptable under government orders, and after the requirements of the tin plate trade are met; (4) steel at mills whose finishing capacity is limited, in the forms in which the government can use steel. Thus, as to the last item, there are mills equipped to roll little but merchant bars, the government requirements in that line being very much less than in plates, for example. There has been talk of attempting to divert ingots or billets from such mills to mills equipped with excess rolling capacity in government forms, but the proposition faces great difficulties.

As to the applicability of bessemer steel uses for which open-hearth has in recent years been given preference, the whims of consumers long recognized by steel makers are being given no attention. Of particular interest is the "sanitary" can, the can which does without solder by employing a tight seam. Since the development of the sanitary can and until quite recently open-hearth steel was regarded as absolutely essential, but practically all sanitary cans are now made of bessemer steel. The tin plate maker has to give the black plate special treatment in annealing. This involves an extra expense but it can readily be done.

Production

Production of pig iron and steel has been steadily increasing, although rather slowly. Blast furnace capacity is estimated conservatively at 43,000,000 tons a year, taking the actual production in 1916 plus a safe allowance for new furnaces completed. Steel ingot capacity is 47,000,000 tons at a conservative estimate. Thus far in May pig iron production has been at 90 per cent of capacity at least, but ingot production has hardly been at as much as 90 per cent of capacity. Whatever might be the experience in normal times, it is quite improbable that 100 per cent operation of the blast furnaces would permit 100 per cent operation of the steel capacity, because there is not sufficient scrap.

Chemical Market

Coal Tar Products: The demand for crudes has not undergone a great deal of change during the interval and continues quiet, with prices easier. The intermediates however are in better demand and prices for the most part are unchanged, with a tendency upward rather than otherwise.

Benzol: Large surplus offerings continue to back up on the market. Consumers are not buying heavily and prices registered further declines.

Phenol: Offers are more liberal, but the demand is light and prices are easier.

Toluol: Producers of the dye intermediates are receiving more liberal releases from the government, but other producers of intermediates are not receiving any. There continues to be small outside offerings at high prices.

Naphthalene: Quiet continues to prevail in this situation. Offers are more liberal, with the demand only routine.

Benzoate of Soda: There appears to be larger quantities of this material on the market than heretofore and prices are easing off as a result.

Dimethylaniline: Only a few producers are offering and prices are holding firm, with an active demand.

Diethylaniline: The production is confined to a few quarters and is not heavy; prices are inclined higher.

Paranitraniline: Only a few producers are offering; prices are higher, with an active demand.

Aniline Oil: Inquiries are numerous with prices unchanged.

Beta Naphthol: The technical grade is quite active, but the sublimed is quiet, with prices unchanged.

Alpha Naphthylamine: More of this material has been moving of late than formerly. Prices are practically unchanged, but the spot supply is lower.

Metatolumylenediamine: Recent releases of toluol have assisted toward increasing the production; the demand is active but not heavy.

Para Amido Phenol: Competing factors keep prices low and the production ample.

Phthalic Anhydride: This item is also lower in price due to the competition prevailing.

HEAVY CHEMICALS: Business in products under this classification has been comparatively slow and unimportant during the past two weeks and the tendency in values has been to lower levels. Trading has mostly been in small lots and consumers apparently will not cover far forward needs at present trading levels. In a few of the products there have been pronounced flurries, due in some instances to speculation and in other directions to sudden demands from consuming trades.

Caustic Soda: A marked decline has occurred in this product since our last report and there has been very little important buying for the account of consumers. Prices have dropped from the level of 5c. store New York down to 4.35, at which offers are noted at the moment of writing. Philadelphia has sold material as low as 4.25. For forward positions producers have also come down in their views and there are now offers noted for contracts over the balance of the year at 4.75 works after the price of 5c. works prevailed for a long time. For 1919 business 3¼c. works basis 60% is quoted but no business is noted.

Soda Ash: This market has also been subject to a sharp decline in values, and at the moment of writing bags are available from New York store at 2.15—the lowest price that has prevailed for a lengthy period. Barrels are held at 2.60 to 2.70 and are somewhat firmer than bags, although there is no special movement noted.

Acetic Acid: This market has been one of the features of the situation the past two weeks. The 28% material has sold as high as 16c. barrels inclusive and the 56% material has sold at the unusually high price of 27¾c. barrels extra. This is probably the highest price on record. The principal accomplishment in the product at the moment is the locating of the supplies. Once stocks are located it is merely a matter of a few moments before the product is sold.

Sulphuric Acid: The market has been easier of late and sixty-six degree brimstone acid has been available as low as $33.00 per ton in sellers tanks works. The producers generally ask $35.00 sellers tanks works for the ordinary run of business. Very few offers of sixty degree material are noted, for as a rule the buyer prefers sixty-six degree material when same is available at a favorable figure. Ninety-seven per cent plus acid has on the other hand been very scarce and offers have been few and far between.

Oleum: The situation has improved the past few days and offers have been somewhat restricted. However it is still possible to do $65 drums extra but returnable for ordinary business. For tanks cars possibly $60.00 is workable. Some business in 60% oleum has been done at $225.00 per ton but the production has now been sold for the entire year and no further offers are noted.

Yellow Prussiate of Soda: The consuming demand has been so urgent that prices have been forced up to 50c., although transactions were noted at 37c. only a week or so ago. The production is confined to a few firms and is apparently not sufficiently large to take care of the consuming demand.

Yellow Prussiate of Potash: In common with most potash products the product is easier and there were offers during the past few days at $1.15 without attracting buyers. This is for American material. Japanese material is generally available at a somewhat lower figure.

Cyanide of Soda: The ordinary seller asks 40c. and upward but from second hands it is possible to do 38c. and on large business even this figure is shaded.

Copper Sulphate: Producers are not inclined to meet second-hand prices, but there is no denying the fact that these quotations are rather well establishing the market. Standard brands are available as low as 8¾c., although makers are quoting 9c. and even 9¼c.

Bichromate of Soda: The market has been such that it has been impossible to fathom it. Business has passed from 21c. up to 25c., and at the moment of writing 23½c. and 24c. is quoted. A few casks offered here and there are 23½c. and then a car is picked up at 24c. No one seems to understand just what is going on and who is doing it, but the product is subject to more fluctuation than any other chemical in this classification.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, MAY 8, 1918

Acetic anhydride	lb.	1 50 —	1 60
Acetone, drums	lb	Nominal	
Acid, acetic, 28 per cent	lb	Nominal	
Acetic, 56 per cent	lb.	Nominal	
Acetic, glacial, 99½ per cent., carboys	lb.	Nominal	
Boric, crystals	lb.	13½ —	14½
Citric, crystals	lb.	87 —	88
Hydrochloric, C P	lb.	Nominal	
Hydrochloric, 20 deg	lb.	02½ —	02½
Hydrochloric, conc., 22 deg	lb.	02½ —	03
Hydrofluoric, 30 per cent., in barrels	lb.	.06 —	06½
Lactic, 44 per cent	lb.	15½ —	16
Lactic, 22 per cent	lb.	06 —	06½
Molybdic, 85 per cent	lb.	3 85 —	
Nitric, 36 deg	lb.	08½ —	08½
Nitric, 42 deg	lb.	09 —	10
Oxalic, crystals	lb.	43 —	45
Phosphoric, 47 50 per cent paste	lb.	08 —	10
Phosphoric, ref 50 per cent	lb.	26 —	
Picric	lb.	Nominal	
Pyrogallic, resublimed	lb.	3 10 —	3 15
Sulphuric, 60 deg	ton	25 00 —	27 50
Sulphuric, 66 deg	ton	35 00 —	40 00
Sulphuric, oleum (Fuming), tank cars	ton	60 00 —	75 00
Tannic, U S P, bulk	lb.	1 30 —	1 35
Tartaric, crystals	lb.	75 —	78
Tungstic, per lb. of W	lb.	1 70 —	1 75
Alcohol, sugar cane, 188 proof	gal.	4 93 —	4 95
Alcohol, wood, 95 per cent	gal.	90½ —	91
Alcohol, denatured, 180 proof	gal.	68 —	69
Alum, ammonia lump	lb	04 —	04½
Alum, chrome ammonium	lb.	18 —	19
Alum, chrome potassium	lb.	20 —	21
Alum, chrome sodium	lb.	12½ —	13
Alum, potash lump	lb.	08½ —	09
Aluminium sulphate, technical	lb.	02½ —	03
Aluminium sulphate, iron free	lb.	03½ —	03½
Ammonia aqua, 26 deg. carboys	lb.	26 —	27
Ammonia, anhydrous	lb.	Nominal	
Ammonium carbonate	lb.	Nominal	
Ammonium nitrate	lb.	(Fixed price)	15
Ammonium, sulphate domestic	lb.	07½ —	08
Amyl acetate	gal.	5 00 —	5 25
Arsenic, white	lb.	17 —	18
Arsenic, red	lb.	65 —	70
Barium carbonate, 99 per cent	ton	80 00 —	90 00
Barium carbonate, 97-98 per cent	ton	65 00 —	67 00
Barium chloride	ton	65 00 —	85 00
Barium sulphate (Blanc Fixe, Dry)	lb	02½ —	02½
Barium nitrate	lb.	09½ —	10
Barium peroxide, basis 70 per cent	lb.	30 —	32
Bleaching powder, 35 per cent. chlorine	lb.	01½ —	02½
Borax, crystals, sacks	lb.	07½ —	08½
Brimstone, crude	ton	Nominal	
Bromine, technical	lb.	75 —	
Calcium, acetate, crude	lb.	Nominal	
Calcium, carbide	lb.	13½ —	14
Calcium chloride, 70-75 per cent., fused, lump	ton	27 50 —	30 00
Calcium peroxide	lb.	1 60 —	1 70
Calcium phosphate	lb.	14 —	35
Calcium sulphate 98-99 per cent	lb.	09 —	09½
Carbon bisulphide	lb.	08½ —	10½
Carbon tetrachloride, drums	lb.	15½ —	16
Carbonyl chloride (phosgene)	lb.	1 10 —	1 50
Caustic potash, 88-92 per cent	lb.	83½ —	84
Caustic soda, 76 per cent	lb	04½ —	04½
Chlorine, liquid	lb.	15 —	18½
Cobalt oxide	lb.	1 60 —	1 65
Copperas	lb.	01½ —	01½
Copper carbonate	lb.	30 —	40½
Copper cyanide	lb.	75 —	78
Copper sulphate, 99 per cent., large crystals	lb	08½ —	09
Cream of tartar, crystals	lb	80 —	82½
Epsom salt, bags, U S P	lb.	03½ —	03½
Formaldehyde, 40 per cent	lb.	18½ —	19½
Glauber's salt	100 lb.	1 50 —	2 00
Glycerine, bulk, C P	lb.	63 —	64
Iodine, resublimed	lb	4 25 —	4 30
Iron oxide	lb.	13 —	15
Lead, acetate, white crystals	lb	17 —	18
Lead, arsenate (Paste)	lb.	15 —	18
Lead nitrate	lb.	15 —	16
Litharge, American	lb.	09½ —	11½
Lithium carbonate	lb.	1 50 —	2 00
Manganese dioxide, U S P	lb	20 —	25
Magnesium carbonate, technical	lb.	10½ —	11
Nickel salt, single	lb	14 —	15
Nickel salt, double	lb	12 —	14
Phosgene, see Carbonyl chloride			
Phosphorus, red	lb.	1 30 —	1 50
Phosphorus, yellow	lb.	1 50 —	1 60
Potassium bichromate	lb	44 —	46
Potassium bromide granular	lb	1 35 —	1 50
Potassium carbonate calcined, 85-90 per cent	lb	40 —	50
Potassium chlorate, crystals	lb	38 —	40
Potassium cyanide, 98-99 per cent	lb	Nominal	
Potassium iodide	lb	3 75 —	3 80
Potassium muriate 80-85 p c. basis of 80 p c	ton	325 00 —	350 00
Potassium nitrate	lb.	27 —	31
Potassium permanganate (U S P)	lb	3 65 —	3 75
Potassium prussiate, red	lb	2 80 —	2 90
Potassium prussiate, yellow	lb.	1 15 —	1 20
Potassium sulphate, 90-95 p c basis 90 p c	ton	Nominal	
Rochelle salts	lb	43 —	44
Salammoniac, gray gran	lb	18 —	19
Salammoniac, white gran	lb	15½ —	16
Salsoda	100 lb	1 35 —	1 40
Salt cake	ton	22 50 —	25 00
Silver cyanide, based on market price of silver	oz		
Silver nitrate	oz	61½ —	62
Soda ash, 58 per cent (light, flat bags)	100 lb	2 20 —	2 30

Soda ash, 58 per cent., dense, flat	100 lb.	3.65	—	
Sodium acetate	lb.	.23	—	.24
Sodium bicarbonate, domestic	lb.	.02½	—	.03
Sodium bicarbonate, English	lb.		—	
Sodium bichromate	lb.	.24	—	.25
Sodium bisulphite, powd	lb.	.05½	—	.06
Sodium chlorate	lb.	.24	—	.25
Sodium cyanide	lb.	.38	—	.40
Sodium fluoride, commercial	lb.	.18	—	.19
Sodium hyposulphite	lb.	.02½	—	.02½
Sodium molybdate, per lb. of Mo	lb.	2.50	—	
Sodium nitrate, 95 per cent	100 lb.	Nominal		
Sodium nitrite	lb.	.29	—	.32
Sodium peroxide	lb.	.48	—	.50
Sodium phosphate	lb.	.04	—	.05
Sodium prussiate, yellow	lb.	.50	—	.52
Sodium silicate, liquid (60 deg.)	lb.	Nominal		
Sodium sulphide, 30 per cent., crystals	lb.	.02½	—	.03
Sodium sulphide, 60 per cent., fused	lb.	.06	—	
Sodium sulphite	lb.	Nominal		
Strontium nitrate	lb.	.25	—	.35
Sulphur chloride, drums	lb.	.06	—	.06½
Sulphur dioxide, liquid, in cylinders	lb.	.15	—	.40
Sulphur, flowers, sublimed	100 lb.	4.05	—	4.60
Sulphur, roll	100 lb.	3.70	—	3.85
Sulphur, crude	ton	Nominal		
Tin bichloride, 50 deg	lb.	.23½	—	.24½
Tin oxide	lb.	.78	—	.80
Zinc carbonate	lb.	.25	—	.30
Zinc chloride	lb.	.12½	—	.13
Zinc cyanide	lb.	Nominal		
Zinc dust, 350 mesh	lb.	.14	—	.16
Zinc oxide, American process XX	lb.	.12½	—	.14
Zinc sulphate	lb.	.05	—	.06

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.27	—	.30
Benzol, 90 per cent	gal.		—	
Toluol, pure, water white	gal.	1.75	—	5.50
Xylol, pure, water white	gal.	.35	—	.50
Solvent naphtha, water white	gal.	.17	—	.22
Solvent naphtha, crude, heavy	gal.	.13	—	.16
Creosote oil, 25 per cent	gal.	.33	—	.35
Dip oil, 20 per ceot	gal.	.29	—	.30
Pitch, various grades	too	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05	—	1.10
Carbolic acid, crude, 50 per cent	lb.	.60	—	.65
Carbolic acid, crude, 25 per cent	lb.	.35	—	.38
Cresol, U. S. P	lb.	.18	—	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00	—	1.25
Alpha naphthol, distilled	lb.	1.60	—	2.00
Alpha naphthylamine	lb.	.60	—	.61
Aniline oil, drums extra	lb.	.25½	—	.27
Aniline salts	lb.	.33	—	.34
Anthracene, 80 per cent	lb.	.50	—	.65
Benzaldehyde (f.f.c.)	lb.	5.50	—	6.00
Benzidine, base	lb.	1.75	—	1.85
Benzidine, sulphate	lb.	1.40	—	1.50
Benzoic acid U. S. P	lb.	4.00	—	4.10
Benzoate of Soda, U. S. P	lb.	3.75	—	3.90
Benzyl chloride	lb.	2.25	—	2.75
Beta naphthol benzoate	lb.	10.00	—	12.00
Beta naphthol, sublimed	lb.	.85	—	.90
Beta naphthylamine, sublimed	lb.	2.65	—	
Diehlor benzol	lb.	.12	—	.18
Diethylaniline	lb.	4.50	—	5.00
Dinitro benzol	lb.	.35	—	.40
Dinitrochlorbenzol	lb.	.40	—	.42
Dinitronaphthaline	lb.	.55	—	.60
Dinitrotoluol	lb.	.55	—	.60
Dinitrophenol	lb.	.46	—	.50
Dimethylaniline	lb.	.65	—	.70
Diphenylamine	lb.	1.00	—	1.10
H-acid	lb.	2.25	—	2.50
Metaphenylenediamine	lb.	2.00	—	2.25
Monochlorbenzol	lb.	.17	—	.19
Naphthalene, flake	lb.	.10	—	.10½
Naphthalene, balls	lb.	.12	—	.13
Naphthionic acid, crude	lb.	1.20	—	1.30
Naphthylamin-di-sulphonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.45	—	.50
Nitro toluol	lb.	.50	—	.55
Ortho-amidophenol	lb.		—	
Ortho-dichlor-benzol	lb.	.15	—	.18
Ortho-toluidine	lb.	1.00	—	1.25
Ortho-nitro-toluol	lb.	.75	—	1.00
Para-amidophenol, base	lb.	3.50	—	3.75
Para-amido-phenol, H. Ch	lb.	4.00	—	5.00
Para-dichlor-benzol	lb.	.12	—	.15
Parasulfraniline	lb.	1.28	—	1.30
Para-nitro-toluol	lb.	1.50	—	1.60
Paraphenylenediamine (base)	lb.	3.00	—	3.25
Para toluidine	lb.	2.25	—	2.50
Phthalic acid anhydride	lb.	3.50	—	4.00
Phenol, U. S. P	lb.	.50	—	.52
Resorcin, technical	lb.	5.75	—	6.00
Resorcin, pure	lb.	8.50	—	9.00
Salicylic acid	lb.	.95	—	1.00
Salol	lb.	1.90	—	2.00
Sulphanilic acid, crude	lb.	.32	—	.35
Tolidin	lb.	2.50	—	
Toluidine-mixture	lb.	.75	—	.85

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4.00	—	
Corning, Ohio	bbl.	2.85	—	
Somerset, Ky	bbl.	2.60	—	
Wooster, Ohio	bbl.	2.58	—	
Indiana	bbl.	2.18	—	
Illinois	bbl.	2.32	—	
Oklahoma and Kansas	bbl.	2.25	—	
Caddo, La., light	bbl.	2.25	—	
Corsicana, Tex., light	bbl.	2.35	—	
California	bbl.	.98	—	1.32
Gulf Coast	bbl.	1.35	—	

Fuel Oil

New York	gal.	.11	—	
Pittsburgh	gal.	.07½	—	.10
Oklahoma-Kans	bbl.	1.05	—	2.75
Texas	bbl.	1.50	—	1.90
Los Angeles	bbl.	1.52	—	
San Francisco	bbl.	1.45	—	

Gasoline (Wholesale)

New York	gal.	.24	—	
Boston	gal.	.25	—	
Pittsburgh	gal.	.28	—	
Chicago	gal.	.22½	—	
Oklahoma	gal.	.25	—	
San Francisco	gal.	.20	—	

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.21	—	.22
Cylinder, light	gal.	.36	—	.38
Cylinder, dark	gal.	.35	—	.36
Paraffine, high viscosity	gal.	.40	—	.41
Paraffine, .903 sp. gr	gal.	.36	—	.38
Parsffine, .885 sp. gr	gal.	.26	—	.28

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	.44	—	
Pine oil, steam-distilled, sp. gr. 0.925-0.940	gal.	.53	—	
Pine oil, destructively distilled	gal.	.49	—	.53
Pine-tar oil, sp. gr., 1.025-1.035	gal.	.35	—	
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.40	—	
Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f. o. b. works	gal.	.35	—	
Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f. o. b. works	gal.	.35	—	
Pine-tar oil, ref., thin, sp. gr. 1.060-1.080	gal.	.30	—	
Turpentine, crude, sp. gr. 0.980-1.000	gal.	.40	—	
Hardwood oil, f. o. b. Michigan, sp. gr. 0.960-0.990	gal.	.19	—	
Hardwood oil, f. o. b. Michigan, sp. gr. 1.06-1.08	gal.	.19	—	
Wood creosote, ref. f. o. b. Florida	gal.	.31	—	

Vegetable and Other Oils

China wood oil	lb.	.26	—	.27
Cottonseed oil, crude	lb.	.17½	—	.18
Linseed oil, raw, cars	gal.	1.57	—	1.59
Peanut oil, crude	gal.	1.37	—	
Rosin oil, first run	gal.	.41	—	
Rosin oil, fourth run	gal.	.58	—	
Soya bean oil, Manchuria	lb.	.19½	—	.19½
Turpentine, spirits	gal.	.44	—	.44½

Miscellaneous Materials

Barytes, floated, white, foreign	ton	Nominal		
Barytes, floated, white, domestic	ton	32.00	—	36.00
Beeswax, white, pure	lb.	.60	—	.62
Casein	lb.	.14½	—	.18
Chalk, light, precipitated, English	lb.	Nominal		
China clay, imported, lump	ton	17.50	—	36.00
China clay, domestic, lump	ton	12.50	—	20.00
Feldspar	ton	8.00	—	12.00
Fluorspar, gravel, f. o. b. mines	ton	33.00	—	35.00
Fuller's earth, powdered	100 lb.	1.00	—	1.50
Graphite, flake	lb.	.15	—	.18
Ozokerite, crude, brown	lb.	Nominal		
Ozokerite, American, refined, white	lb.	Nominal		
Red lead, dry, carloads	lb.	.10	—	.11½
Rosin, 280 lb	bbl.	6.15	—	
Soapstone	ton	10.00	—	12.50
Talc, American, white	ton	15.00	—	22.00
White lead, dry	lb.	.09	—	.10

Refractories, Etc.

(F. O. B. Works)

Chrome brick	net ton	Nominal		
Chrome cement, Greciaa	net ton	Nominal		
Clay brick, 1st quality fireclay	per 1000	50.00	—	55.00
Clay brick, second quality	per 1000	35.00	—	40.00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined	ton	32.00	—	35.00
Magnesite, Grecian, dead burned	net ton	70.00	—	75.00
Magnesia brick, Grecian, 9x4½x2½	net ton	130.00	—	135.00
Silica brick	per 1000	50.00	—	60.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent., carloads, f. o. b. Niagara Falls, N. Y	ton	200.00	—	
Ferrocerium	lb.	20.00	—	
Ferrochromium, per lb. of Cr	lb.	.50	—	
Ferromanganese, domestic, 70 per cent. basis	ton	250.00	—	
Ferromanganese, English	ton	325.00	—	
Ferromolybdenum, per lb. of Mo	lb.	5.00	—	
Ferrosilicon, 75 per cent., f. o. b., N. Y	ton		—	
Ferrosilicon, 50 per cent., carloads, del., Pittsburgh	ton	180.00	—	190.00
Ferrosilicon, 50 per cent., contract	ton	100.00	—	175.00
Ferrotungsten, 75-85 per cent., f. o. b., Pittsburgb	lb.	2.35	—	2.40
Ferrouranium, f. o. b. works, per lb. of U	lb.	7.00	—	7.50
Ferrovanadium, f. o. b. works	lb.	4.00	—	5.00

Ores and Semi-finished Products

Antimony ore, per unit		1.60	—	1.75
Chrome ore, 45 per cent. minimum, f.o.b. Cal., per unit	ton	1.40	—	1.60
Chrome ore, 45 per cent. and over, New York, per unit	ton	1.50	—	
Maoganese ore, 48 per cent. and over, per unit	ton	1.20	—	
Manganese ore, chemical	ton	80.00	—	100.00
Molybdenite, per lb. of MoS_2	lb.	1.80	—	
Tungsten, Scheelite, per unit of WO_3	ton	24.50	—	
Tungsten, Wolframite, per unit of WO_3	ton	24.00	—	
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	
Pyrites, foreign	unit	.17	—	.17½
Pyrites' domestic	unit	.28	—	.30

INDUSTRIAL

Financial, Construction and Manufacturers' News

New Companies

The ALLEN MANUFACTURING COMPANY, Quakertown, N. J. Capital, $10,000. To engage in the manufacture of chemicals and allied products. Incorporators: Harry W. Hayer, Walter A. Allen, Harry M. Oakes and George E. Rose, Quakertown.

The AMERICAN INGRAFT COMPANY, INC., New York. Capital, $25,000. To manufacture chemicals, etc. Morris Yedlin, Brooklyn, is the principal incorporator.

The BROWN CHEMICAL COMPANY, Maplewood, N. J. Capital, $500,000. To manufacture chemicals and allied specialties. Incorporators: Oscar G. Brown, F. M. Brown, Maplewood, and Arthur C. Hamilton, West Orange.

The CAPSTAN GLASS COMPANY, Philadelphia, Pa. Capital, $300,000. To engage in the manufacture of glass and glassware. Incorporators: H. A. Stein, Sharon Hill, Pa.; J. V. Pimm and S. C. Seymour, Camden, N. J.

The CHRISMAN PARAFFINE PAINT WORKS, INC., Eldrad, Pa. Capital, $20,000. To manufacture paints, varnishes, &c. Incorporators: Benjamin G. McFall, Bruce H. Clark and Frank F. Mack, Eldrad, Pa.

KELLY BROTHERS MANUFACTURING COMPANY, Belington, W. Va. Capital, $50,000. To operate a local foundry. Incorporators: J. F., M. J. and J. P. Kelly, Elkins; J. A. and H. V. Viquesney, Belington.

The KNICKERBOCKER DYESTUFF COMPAY, New York. Capital, $10,000. To engage in the manufacture of dyestuffs, etc. Incorporators: M. Mackenzie, A. H. Gleason and J. J. Hayden, 258 Broadway.

The MANCHESTER SUGAR COMPANY, Boston, Mass. Capital, $50,000. To manufacture sugar. Incorporators: Benjamin P. Levy, N. Harrison and I. Gordon, Boston.

The MALMEE IRON & STEEL COMPANY, Toledo, O. Capital, $50,000. To engage in the manufacture of iron and steel products. George W. Ritter is the principal incorporator.

The METRO COLOR & CHEMICAL WORKS, Brooklyn, N. Y. Capital, $75,000. To operate a plant for the manufacture of chemicals, dyestuffs, etc. Incorporators: A. Petersen, M. Goldhammer and R. Jensen, 760 St. Ann's Avenue.

The MIDDLESEX RENDERING COMPANY, Middletown, Conn. Capital, $25,000. To operate a local rendering plant. Incorporators: Berkley C. Stone, Frank H. Frissell and Dennis J. O'Brien, Middletown.

The NEW ERA ORE REDUCTION COMPANY, Philadelphia, Pa. Capital, $2,500,000. To engage in the development of mining properties and the reduction of ore. Incorporators: Wray C. Arnold, Harold C. Lansinger and M. Elliott, Philadelphia.

The O'BRIEN SYNTHETIC DYE COMPANY, South Bend, Ind. Capital, $50,000. To manufacture chemicals, dyestuffs, etc. Incorporators: Jerome J. Crowley, George L. O'Brien, Will G. Crabill, S. J. Crumpacker and Ray Heylman, South Bend.

The POUGHKEEPSIE PAINT COMPANY, Poughkeepsie, N. Y. Capital, $10,000. To manufacture paints, varnishes, etc. Incorporators: H. Lloyd, Jr., C. and H. Sague, Poughkeepsie.

The PROSPECT PAINT COMPANY, Bronx, N. Y. Nominal capital, $5,000. To operate a plant for the production of paints. Incorporators: F. Eisen, S. Roth and S. Hauptman, 1066 Prospect Avenue.

The PYODINE CHEMICAL COMPANY, Los Angeles, Cal. Capital, $25,000. To engage in the manufacture of chemicals, etc. Incorporators: Dr. David Osterhold, E. Osterhold and Fred E. Osterhold, 1141 North Coronado Street.

The PYROPHORIC METALS COMPANY, Newark, N. J. Capital, $100,000. To deal in metals and alloys. Incorporators: George W. Cunningham, Paterson; William E. Bloomfield, and William Bonnamy, Passaic, N. J.

The SEMINOLE PHOSPHATE MINING COMPANY, Croom, Fla. Capital, $20,000. To mine for phosphate. Incorporators: W. F. Walker, E. N. Morrow, Croom, and A. I. Pelway, Eastman, Ga.

The VELORA COMPANY, New York. Capital, $250,000. To engage in the manufacture of chemicals, etc. Incorporators: E. S. M. Selig, A. B. Crawford and F. Aranow, 27 Cedar Street.

S. WALTER, INC., Philadelphia, Pa. Capital, $75,000. To engage in the manufacture of paper and paper products. Harry Lefkowith is the principal incorporator.

The WATERVILLE FOUNDRY & MANUFACTURING COMPANY, Waterville, N. Y. Capital, $25,000. To operate a foundry for the manufacture of castings and machinery. Incorporators: William G. McLean, Charles W. McLean, Waterville, and George I. Hovey, Deansboro.

The WEST VIRGINIA LEAD & ZINC COMPANY, Parkersburg, W. Va. Capital, $300,000. To engage in the development of lead and zinc properties in the Miami district, Okla. Incorporators: Charles Heinselman, A. D. Sees, A. A. Haught and H. B. Reid.

The WILMINGTON PAINT & GLASS COMPANY, Wilmington, Del. Capital, $50,000. To operate a plant for the manufacture of paints, glass, etc. Incorporators: Harry B. Patten, William F. Johnson and John L. Byrne, Wilmington.

Constructions and Operation

Connecticut

HARTFORD.—U. S. Ordnance Corps, Washington, D. C., will build a plant here and install machinery for producing toluol from gas. Hartford City Gas Co., 565 Main St., will produce about 50,000 gal.

NEW BRITAIN.—The New Britain Machine Co., Chestnut St., has purchased a site of land on South St. on which they plan to construct a 100 x 310 ft factory to cost approximately $125,000.

Georgia

MACON.—The Macon Gas Co. will build a $40,000 addition to its plant, increasing the monthly capacity to 36,000,000 cu. ft gas for lighting and heating.

Illinois

CHICAGO.—Bauer & Black, 25th St and Dearborn Ave., manufacturer of druggist specialties, will build a 7-story, 75 x 108 reinforced concrete addition to factory. Hobart & Roche, 1101 Monroe Bldg., architects.

CHICAGO.—Harrington & King Co., 614 North Union Ave., manufacturer of perforated sheet metal, will build a 1-story 126 x 372 ft mill construction factory at Campbell and Taylor Sts. George C. Nimmons & Co., 2005 Peoples Gas Building, engineer.

Kentucky

NEW ALBANY.—The United Chemical Co., 111 West Washington St., Chicago, Ill., has acquired a tract of land in New Albany comprising about 55 acres on which they plan to construct a large plant for the manufacture of chemicals.

Maine

BIDDEFORD.—The Saco-Lowell Shops, Biddeford, has awarded the contract for the construction of a 1-story, 56 x 92 x 107 ft. brick and steel factory addition to the Flint Building & Construction Co., 146 Main St., Palmer, Mass.

Maryland

BALTIMORE.—The Bartlett Hayward Co., Scott and McHenry Sts., has awarded the contract for the construction of a 1-story, 50 x 75 ft. assembly shop to the Bruce Foundry Bldg., Baltimore, at a cost $55,000.

CLEVELAND.—The Kelly-Springfield Tire Co., Cook St., Akron, Ohio, will build a new plant here to cost approximately $1,000,000.

Massachusetts

HOLYOKE.—The Worthington Pump & Machinery Corporation, Beane Works, Appleton St., is planning to build a 150 x 200 ft. machine and erecting shop, and a 50 x 300 ft. foundry, brick and steel frame. Estimated cost, $225,000. Lyman R. Howes, c/o Beane Works, is engineer.

SOMERVILLE.—The Vacuum Co., 105 Mystic Ave., has awarded the contract for the construction of a 2-story, 60 x 198 ft. timber fumigating plant on concrete pile foundation, to Barney Ahlers Corporation, 110 West 40th St., New York City. Estimated cost, $15,000.

Michigan

DETROIT.—The Packard Motor Car Co., East Grand Boulevard, will build an addition to its factory on Mt. Elliott Ave., to cost $15,000.

Minnesota

MINNEAPOLIS.—Goldberg Bros., 922 Washington Ave., will build a 1-story, 13 x 40 x 80 ft., brick brass foundry by day labor. Estimated cost, $4,500.

New Jersey

KEARNY.—(Arlington P. O.)—Swift & Co., Union Stock Yards, Chicago, Ill., will build a 5 story, reinforced concrete rendering plant on the Kearny Meadows to have a capacity of approximately 3,000,000 pounds of raw product. The company plans to complete the plant in three months and it will probably be the largest works of its kind in the east.

BLOOMFIELD.—The General Electric Co., Sprague Works, has awarded the contract for the construction of a 1-story, 100 x 160 ft., reinforced concrete steel and brick factory, to Austin Co., 16112 Euclid Avenue, Cleveland, Ohio. Estimated cost, $35,000

HASKELL.—The E. I. duPont de Nemours Co., Wilmington, Del., is building a 1-story, 20 x 40 ft. addition to its plant here. James Lynah is superintendent.

NEWARK.—The Rutterworth Judson Corporation, Avenue R, manufacturer of chemicals, has had plans prepared for the construction of a 1 story, brick and steel absorption tower at its plant here. Estimated cost $30,000.

New York

BROOKLYN.—The Long Island Soap Co., Bridgewater St. and Meeker Ave., has awarded the contract for the construction of a 3 story, reinforced-concrete factory, to the Gabler Construction Co., 402 Hudson St., New York. Estimated cost, $38,000

NEW YORK.—The American Balso Corporation, manufacturer of chemicals, 20 East 42nd St., has awarded the contract for the construction of a 1 story, 138 x 185 ft., concrete, brick and steel factory to be built at the foot of 153rd St. and Harlem River to C. G. Flygar, 405 Lexington Ave., New York. Estimated cost, $70,000.

NEW YORK.—The Vulcan Proofing Co., 583 Dean St., Brooklyn, has awarded the contract for the construction of a 2 story 120 x 208 ft. concrete factory on 57th St., west of 1st Ave., to Turner Construction Co., 244 Madison Ave., New York. Estimated cost, $200,000.

TUCKAHOE.—The Hodgeman Rubber Co. has awarded the contract for the construction of a 1 story 60 x 160 ft. concrete, brick and steel factory to cost $20,000 to Austin Co., 16112 Euclid Ave., Cleveland, Ohio.

WATERTOWN.—Fire May 4 destroyed the machine mill at the plant of the International Paper Co., on Sewalls Island with a loss of approximately $150,000. The company plans to rebuild same.

North Dakota

GRAND FORKS.—The University of [illegible] has awarded the contract for the construction of a 3 story chemistry building to the Dakota Construction Co., Grand Forks, Minnesota. Mine [illegible]

Ohio

AKRON.—The Goodyear Tire & Rubber Co., Main St., has awarded the contract for the construction of a 1 story

170 x 460 ft., steel, brick and concrete balloon factory, to the Hankin-Conkey Construction Co., 321 Cuyahoga Building, Cleveland. Estimated cost, $450,000.

AKRON—The Phoenix Rubber Co., Wrigley Ave. has awarded the contract for the construction of a 1 story, 50 x 100 ft., and a 1 story, 30 x 30 ft., brick and steel frame factory, to Clemmer & Johnson Co., High and Church Sts., Akron, to cost, $8000.

CINCINNATI—The Cincinnati Ball Crank Co. plans to build a brick machine shop as an addition to its factory at 3167 Densey Ave., Oakley. Estimated cost, $35,-000.

CINCINNATI—The contract has been awarded to the Fisher-DeVore Electric Co. for the construction of a 6 story, reinforced concrete plant for the Lullaw-Dunn-Gordon Co., machine tool manufacturers. Estimated cost $90,000.

CINCINNATI—The Peerless Foundry Co., 11th and High Sts., Hamilton, will build a 120 x 200 ft. grey iron foundry, fireproof construction.

CINCINNATI—The United States Electric Tool Co. plans to build a 2 story, brick manufacturing building at 2488 West 6th St. Estimated cost, $15,000.

CLEVELAND—The Aluminum Rolling Mills Co., Ivanhoe Rd., will build a 1 story 81 x 399 ft., concrete, brick, and steel aluminum rolling mill. Estimated cost, $100,000.

CLEVELAND—The Globe Machine & Stamping Co., 1250 West 76th St., has awarded the contract for the construction of a 4 story, 100 x 150 ft., steel and brick metal factory, to Craig Curtis Co., 1031 Guardian Bldg., Cleveland. Estimated cost $125,000.

CLEVELAND—The Hoffman Bronze Co. Addison Rd., has awarded the contract for the construction of a 1 story, 50 x 101 ft., brick bronze foundry, to A. H. Howard, 1528 Larchmont Ave., Cleveland. Estimated cost, $10,000.

CLEVELAND—The Masek Glue Co., 908 Denison Ave., has awarded the contract for the construction of a 1 story, 30 x 60 ft., brick and steel glue factory, also a 2 story, 20 x 88 ft., reinforced concrete, brick and steel reduction plant, to the Masters & Mullen Construction Co., Electric Building, Cleveland. Estimated cost, $40,000.

CLEVELAND—The Parrish-Bingham Co., 10600 Madison Ave., has awarded the contract for the construction of a 1 story, 120 x 144 ft. building for hardening and picking steel, to W. I. Thompson & Son Co. Estimated cost, $30,000.

CLEVELAND—The Standard Foundry and Manufacturing Co., 2717 East 75th St., has awarded the contract for the construction of a 1 story 35 x 100 ft., brick and steel factory, to D. Lindhorst Construction Co., 807 American Trust Building, Cleveland. Estimated cost $5,000.

DAYTON—The Machines Co., Essex Ave., will build a 3 story, 70 x 150 ft., reinforced concrete and brick factory for the manufacture of optical instruments. Estimated cost, $75,000.

DAYTON—The Ohmer Fare Register Co., Bolander Ave., has awarded the contract for the construction of a 1 story 90 x 300 ft., reinforced concrete, steel, and brick factory to cost $50,000, to Blanchard Contracting Co., 601 Reibold Building, Dayton.

Pennsylvania

CHESTER—John A. Worrell, 905 West 8th St., will construct a 1 story brass foundry at 8th and Springwell Sts.

PHILADELPHIA—The American Manganese Bronze Co., Rhawn and Hegerman Sts., has had plans prepared for the construction of an addition to its foundry in Holmesburg.

PHILADELPHIA—The Fairmount Foundry Co., Mascher and Duncannon Sts., will construct a 1 story, 22 x 100 ft., addition to its foundry.

PHILADELPHIA—John T. Lewis & Sons Co., Lafayette Building, has awarded the contract for the construction of a 1 story, 108 x 180 ft., brick and steel building, at Aramingo and Huntingdon Aves., to the Turner Concrete Steel Co., 1713 Sansom St., Philadelphia. Estimated cost, $10,000.

PHILADELPHIA—Wm. Sellers & Co., 16th and Hamilton Sts., will build a 5 story, 27 x 50 ft., brick, concrete, and steel addition to its plant to be used as an injector shop, to cost $15,000.

PHILADELPHIA—C. F. Simmons Sons, Belgrade and Tioga Sts., has awarded the contract for the construction of a 1 story 35 x 100 ft., brick factory addition for the manufacture of fertilizers and oils, to Harry Gill, Jr., 2515 Germantown Ave. Estimated cost $7000.

PITTSBURGH—The E. R. Moore Co., Union Bank Building, has awarded the contract for the construction of a 1 story, 65 x 200 and 60 x 160 ft., reinforced concrete, brick and steel factory building, to Austin Co., 16112 Euclid Ave., Cleveland, Ohio. Estimated cost $45,000.

Rhode Island

PAWTUCKET—The Narragansett Machine Co., Vale St., has awarded the contract for the construction of a 2 story 60 x 130 and 50 x 86 ft. reinforced concrete, brick and steel manufacturing building, to W. H. Hamlyn & Son., 35 Greenwich St., Providence. Estimated cost, $50,000.

Tennessee

CHATTANOOGA—(Alton Park)—The F. J. Lewis Manufacturing Co., 2513 South Robey St., Chicago, Ill., manufacturer of roofing, etc., has purchased a site at Alton Park on which they plan to construct a branch factory.

Virginia

PULASKI—The Pulaski Foundry & Manufacturing Co. plans to build an addition to its foundry here which will double the present capacity.

Wisconsin

CUDAHY—The Great Lakes Rubber Co., Milwaukee, recently incorporated, plans to construct a factory here for the production of molded and mechanical rubber goods. First unit of plant will provide for 40,-000 sq. ft. space. Donald C. Barbee, 140 Reed St., Milwaukee, is interested.

MILWAUKEE—The Federal Malleable Co., 299-323 Sixty Fourth Ave., plans to build an addition to its foundry at West Allis.

WATERTOWN—The Monarch Tractor Co., Watertown, has awarded the contract for the construction of a 140 x 160 ft., brick and steel machine shop and assembly unit, to the Austin Co., 16112 Euclid Ave., Cleveland, Ohio.

New Publications

THE COLLAPSE OF SHORT THIN TUBES. By Prof. A. P. Carman of the University of Illinois. Bulletin 99 of the Engineering Experiment Station, Urbana, Ill.

THE REPUBLIC OF BOLIVIA. Official Information and Statistics, Summarized by Señor Julio Zamora, Minister of Foreign Relations, Woolworth Bldg., New York.

EMERGENCY TRAINING IN SHIPBUILDING. Description of Evening and Part-Time Classes for Shipyard Workers. Bulletin No. 3 of Federal Board for Vocational Education, Washington.

MECHANICAL AND TECHNICAL TRAINING FOR CONSCRIPTED MEN. (Air Division U. S. Signal Corps). Bulletin No. 4, Federal Board for Vocational Education, Washington.

MINERAL INDUSTRIES OF THE UNITED STATES. The following publications have been issued by the Smithsonian Institute, Washington. Bulletin 102, Parts 1, 2 and 3: Coal Products. By Chester G. Gilbert; Fertilizer. By Joseph E. Pogue; Sulphur. By Joseph E. Pogue.

NEW BUREAU OF MINES PUBLICATIONS: The Mining Industry in Alaska. By S. S. Smith. Bulletin 153.

NEW BUREAU OF STANDARDS PUBLICATIONS: Combined Table of Sizes in the Principal Wire Gages. Circular 67. Gas Interferometer Calibration. By J. D. Edwards. Scientific Paper No. 316; Latent Heat of Vaporization of Ammonia. By Nathan S. Osborne and M. S. Van Dusen. Scientific Paper No. 315; Latent Heat of Pressure Variation of Liquid Ammonia. By Nathan S. Osborne and M. S. Van Dusen. Scientific Paper No. 314; Specific Heat of Liquid Ammonia. By Nathan S. Osborne and M. S. Van Dusen. Scientific Paper No. 313; Comparative Tests of Porcelain Laboratory Ware. By C. E. Waters. Technologic Paper No. 105; Determination of Muntz Metal by Selective Corrosion. By H. S. Rawdon. Technologic Paper No. 103.

NEW GEOLOGICAL SURVEY REPORTS: Arsenic, Bismuth, Selenium and Tellurium in 1916. By Joseph B. Umpleby; Iron Ore, Pig Iron and Steel in 1916. By E. F. Burchard; Gold, Silver, Copper, Lead and Zinc in Colorado in 1916. By C. W. Henderson; Gold, Silver, Copper, Lead and Zinc in Utah in 1916. By V. C. Heikes; Gold, Silver, Copper, Lead and Zinc in Nevada in 1916. By V. C. Heikes; Sulphur, Pyrite and Sulphuric Acid in 1916. By F. S. Smith; Cement in 1916. By E. F. Burchard; Borax in 1916. By C. G. Yale and H. S. Gale; Magnesite in 1916. By C. G. Yale and H. S. Gale.

COAL: The resource and its full utilization. By C. G. Gilbert and J. E. Pogue. Smithsonian Institution Bulletin 102, Part 4. U. S. National Museum, Washington, D. C.

THE ELECTRICAL PROPERTIES OF SOME HIGH RESISTANCE ALLOYS. By M. A. Hunter and F. M. Sebast. Publication of Electrical Engineering Dept., Rensselear Polytechnic Institute, Troy, N. Y.

CATALOG OF RARE AND STANDARD BOOKS on exact and applied Science, including the scientific portion of the library of the late Sir James Stirling, and selections from those of George Rennie, and Samuel Roberts. Issued by Henry Sotherant Co., London, Eng. price 2/6.

BUREAU OF MINES PUBLICATIONS. Bulletin 135, Combustion of Coal and Design of Furnaces, by Henry Kreisinger, C. E. Augistine and F. K. Ovitz. Technical Paper 183. New Views of the Combustion of the Volatile Matter in Coal, by S. H. Katz. Technical Paper 181, Determination of Unsaturated Hydrocarbons in Gasoline, by E. W. Dean and H. H. Hill.

USEFUL MINERALS OF THE UNITED STATES, compiled by F. C. Schrader, R. W. Stone, and S. Sanford. Geological Survey Bulletin 624.

BUREAU OF STANDARD PUBLICATIONS. Technologic Paper 102. Properties of Portland Cement having a high Magnesia Content, by P. H. Bates. Circular No. 44, Polarimetry, 2nd edition.

NEW BUREAU OF STANDARDS PAPERS: No. 99, Gas-Mantle Lighting Conditions in Ten Large Cities in the United States. By R. S. McBride, and C. E. Reinicker. No 95, Durability of Cement Drain-tile and Concrete in Alkali Soils. By R. J. Wig, G. M. Williams, A. N. Finn, S. H. McGrory, E. C. Bebb, and L. R. Ferguson. No 310, Some Electrical Properties of Silver Sulphite, by George W. Vinal.

BULLETIN NO. 16, MINERAL SPRINGS OF CANADA (in two parts). Part 1. The Radioactivity of some Canadian Mineral Springs. By John Satterly and R. T. Elworthy. Issued by the Canadian Department of Mines, Ottawa, Can.

Manufacturers' Catalogs

DRIVER-HARRIS COMPANY, Harrison, N. J., have recently issued a bulletin on the subject of pure sheet nickel. Another bulletin on "Nichrome" wire mesh containers for heat treating and acid cleaning is in the course of preparation.

THE BAILEY METER COMPANY, 141 Milk St., Boston, Mass., has issued Bulletin No. 41 entitled "How to Save Coal."

THE JEFFREY MANUFACTURING CO., Columbus, Ohio, has issued Catalog 231, describing Jeffrey storage battery locomotives for industrial plants.

THE LINK-BELT CO., Chicago, Ill., has issued Book No. 358 describing Link-Belt roller chain.

THE MERCHANTS NATIONAL BANK, 28 State St., Boston, Mass., has issued through its Textile Dept. a booklet on the Motor Truck Problem in the textile and allied industries.

THE WHEELER CONDENSER & ENGINEERING CO., Carteret, N. J., has issued a handbook of steam tables especially for condenser work.

THE MAGNESIA ASSOCIATION OF AMERICA, 702 Bulletin Bldg., Phila. Pa., has issued the first Anniversary Portfolio of the Magnesia Association, under the general title "Let 85% Magnesia Defend Your Steam." The book is a large assemblage of all the educational publicity regarding this insulation which has been appearing during 1917.

LUDLUM ELECTRIC FURNACE CORPORATION, Woolworth Bldg., New York, has published a catalog of its furnace for making cast steel, cast iron, low-phosphorus pig iron and washed metal from low-grade iron and steel scrap. Four points of excellence in design and operation are discussed. The furnace is made in 5, 10 and 15-ton sizes.

HUNGERFORD & TERRY, INC., Philadelphia, have issued a new catalog on water filters for industrial purposes, describing pressure and gravity filters and water softeners.

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Americanism

IF WE do not beat the Germans they will beat us. If the war should end in a draw it is also likely to involve a German victory of the most sinister kind, and for this reason: Unless they become ashamed of themselves in the light of defeat—which seems their only possible source of illumination—Germans who acknowledge the Imperial Government as it is constituted will continue in their abject obedience to any representative of Imperial Authority. They will proceed to lie and practise deceit and offer bribes and foment discord and do any dirty trick they are told to do. Any precious Regierungsassessor or Rat (which is a much-wished-for and instructive title), represents the All-Highest, and it is the interpretation of the wishes of the All-Highest through these media which is the unwritten German law that knows neither ethics nor honor.

Let us hope, however, that in time the German army and navy will be sufficiently shot up to see that it does not pay to rob and steal, and torture prisoners and commit atrocities to show their barbarous prowess, and that finally they may be driven home to worry out their salvation around their own hearthstones. Even then we shall have a stupendous task before us. How long it will be before these acknowledged world-butchers will be allowed to sit at table in conference or stand on the same footing with self-respecting men, whether white or yellow, rests in the hidden lap of the future. To meet them as equals in their present temper, also means defeat. We have gone to war because the Germans were not good enough, and we mean good in the old-fashioned sense of living in sympathy, and taking responsibility for all men of good-will. We have learned already that it will not do to take German ways for our example any more, although we acknowledge the German people to be brave and loyal and competent and efficient. The point is that ethically they have become blind.

Somehow, in the new order of things, we must be strong in many places where we have been weak, if we would avoid the pariah fate of the Germans. New conventions of righteousness must be established. They must become part of the folkways, or attitudes of mind that we expect of everybody. We have dwelt in somewhat of a fool's paradise, leaving admonition to the clergy and rules of conduct to the legislators. But the clergyman has had his own establishment to advance, and his emphasis upon unimportant delinquencies in the interest of his organization has cost him his post of ethical arbiter. The legislator records public opinion in the laws which he helps to enact; he rarely makes public opinion. Moreover, writing ambitions upon the statute books, as we often do, is far from fruitful in good results.

We repeat, there must be new conventions of righteousness established if we are to go forward as a nation on the one hand and avoid the depravity of the Germans on the other. These new conventions will have to do rather with things to be accomplished than with things forbidden. We have seen some very mean and pernicious exploitations of labor in this country and the trouble isn't cured when the evil practices are made illegal. The employment of labor carries with it grave responsibilities; responsibilities that go far beyond the mere purchase of work. And one of the first of these is to see to it that good men and women who do not know the national language and customs shall have a chance to learn them and to become American citizens.

One of the most illuminating men we ever met started in this country as a Neapolitan laborer, in a gang, under a padrone. He could neither read nor write Italian and he knew no other speech. An explosion of dynamite killed a number of his fellows and he was picked up for dead with the upper part of his face, including his eyes, blown clean away. A spark of life was left in him, so he was taken to the hospital where he became interesting for the sole reason that he did not die. When he recovered he was by good fortune sent to that best of the institutions for the blind at Overbrook, Pennsylvania, where he learned first to read and write his own language. Then he mastered English, then French and Spanish and German and then, out of sport and to help him in his work, he took up Russian and a number of other Slavic languages. He now wanders about by himself in New Jersey and Pennsylvania, looking up neglected blind persons and sees to it that they are taught to read Braille, to write on a typewriter, and that they learn trades. Free and with all his faculties, he would have remained a Guinea, worth so much a day and no more, housed in a shack and with no outlook upon life.

Such qualities of exalted citizenship are here and they are available; available, we might almost say, on every hand. If they are turned into destructive channels there is usually a reason why. The incidence of blame is in neglect, and we are learning where to look for it. The time has already arrived when employers must pay something more than wages to their men with hands. The laws generally make it unprofitable to avoid the assurance of physical safety, but that is not all. These men and women must have the chance to become good Americans, they must have decent housing conditions, their children must have good schooling and the opportunity to grow up without corrupting influences.

We know an old gentleman who employs about a thousand men and women. It is surprising to note, in talking with them at hap-hazard, the breadth of mind, the sanity of view and the general indications of culture among them. These qualities seem to increase according to their periods of employment in his establishment. He doesn't preach or lecture or make any fuss over them. He doesn't put on airs or patronize them. But he puts into his daily task the kind of headwork and heart-work that American employers must learn to exercise lest they fail in greater measure than bankruptcy itself; lest they fail in the ideals for which our boys are giving their lives.

The Present Situation in Oil Shale

SOMETHING verging on an old-fashioned "boom" is taking place in oil shales, if the word of the promoter is accepted without discount. Up and down the busiest streets of more than one Western city may be seen show windows containing a mercury retort heated by a plumber's torch, a condenser and one or two Wolff bottles, with which apparatus "liquid gold" or "pure oil" is extracted from a heap of dirt tastefully arranged alongside. Posters remind the observer that three cents invested in Bell Telephone netted three dollars (or thirty dollars—depending upon the fancy of the sign artist) while the furnishing of the office itself consists principally of a desk inhabited by a more oily and efficient gold-extractor in human guise.

The activity of many of these paper companies is no doubt made possible by the lack of "blue-sky" laws, and inspired by the recent report of D. E. Winchester of the U. S. G. S. estimating the amount of material recoverable from the shales in Colorado alone to be of the order of twenty billion barrels of crude oil, two billion barrels of gasoline, and three hundred million tons of ammonium sulphate. Assuming at least an equal amount locked up in the same but less well examined formation in Utah and Wyoming, it appears that here is a reserve of oil products with many times the total holdings of our combined oil fields.

It will probably be found that there will be little profit in mining and distilling shale to sell to outside refining companies. As in other industries, the refinery, the slaughter house, and the smelter will make the sure profit. Again, most of the available analyses show a resulting high-sulphur crude which is already a drug on the market, and would be heavily penalized by existing refineries, if, indeed, it would be accepted. Economically, it seems that good financial results would only follow from operations sufficiently large to provide crude for an individual refinery, which preferably should crack the oil for the maximum yield of light distillate. Such a plant, together with equipment for the recovery of ammonia, will evidently require strong financial backing and excellent technical direction.

Time to Reverse the Old Adage

ON another page we publish a concrete, forward-looking suggestion relating to business and industry in this country after the war. Slow to enter the war, we have also been more deliberate than our European neighbors in anticipating post-war conditions, and preparing as far as possible to meet them.

We believe that no more constructive forces can be thrown into this work than those technical societies representing the industries that have undergone great expansion as a result of the war. The American Electrochemical Society already has decided to devote its next general meeting to a symposium on the future of our electrochemical industries. It seems quite likely that the American Chemical Society, the American Institute of Mining Engineers and the other great national engineering bodies would be of equally great assistance in shedding light on the problems of reconstruction, by scheduling post-war conditions as a subject for consideration at their next general meetings.

A New Turn in Flotation Litigation

THE latest turn of the kaleidoscope of flotation litigation has changed altogether the design and figure to which we had almost become accustomed as one legal decision followed another. With the decision of the Ninth Circuit Court of Appeals, reversing the decision of Judge Bourquin of the District Court in Montana, Minerals Separation is again put sharply on the defensive and the several defendants see the light of possible victory.

Important consequences flow from the latest turn in the litigation, not the least of which is the probability that the United States Supreme Court will again hear the case. But of more immediate satisfaction to the industry must be the clarification of several points that have been as cloudy as some of the scientific theories advanced to explain the process. In the first place, monopoly of the patent in suit is held to be limited to "a (specific) fraction of one per cent" of oil, and that fraction is 0.5 per cent. Second, the allegation that the use of more than one per cent of oil is an evasion of the patent monopoly, is completely upset, and a technicality is wiped out by a saner interpretation of the former testimony. The three judges were in concurrence save on the question of evasion in the use of more than one per cent of oil.

Sacrifices for the Steel Industry

NO PARTICULAR credit accrues to anyone who makes an ordinary sacrifice in these times, for the very fact that it is an ordinary sacrifice deprives it of any distinction. It is with no thought of suggesting that the steel industry deserves particular commendation for what it does that reference is here made to some little sacrifices it finds occasion to make. It is interesting, however, and perhaps stimulating, to mention a few items.

When the steel industry agreed to the "one price for all" dictum of President Wilson it made what was clearly a sacrifice, in the light of existing conditions, because it renounced the opportunity to accept commercial orders that were being offered at much higher prices than those set through the medium of the agreement. The extent of that particular sacrifice in the matter of prices has been gradually reduced until by this time it has really disappeared. It must not be forgotten that the agreement had in it some aspects of a compromise, in that the prices agreed upon, to form the basis of all sales except sales of commercial material for export, were undoubtedly somewhat higher than the Government would have insisted upon to apply in the case of its own purchases. Through the agreement the steel makers have received lower prices on commercial steel, and higher prices on war steel, than would otherwise have been the case. With the diverson of by far the major portion of the output to the filling of war orders the importance of this extra price on war steel is increased.

It is a very important sacrifice that the steel mills make when they ruthlessly cut off deliveries to old and valued customers for the purpose of diverting the maximum possible tonnage to the war work. The great majority of mills have made this diversion very willingly. It would be very unjust to the mills if this diversion were not made universal, for the slackers would thereby be making friends among commercial consumers who might therefore be disposed to patronize them in future, to the disadvantage of the mills which had renounced their trade when called upon to do so for the public good.

Of particular interest is the business sacrifice many steel producers have made in urging their customers to seek substitute materials. The most conspicuous example of this has been the tin-plate trade. The co-operation of that trade with the Government was, moreover, the earliest. Before the country actually declared war the tin-plate makers had pledged themselves to Secretary of Commerce Redfield that they would undertake to divert a maximum quantity of tin-plate to the packing of the perishable food products. That trade is the least stable of the industry's customers, its patronage being seasonal and dependent chiefly upon the magnitude of the crops Nature provides. For years the tin-plate mills have been endeavoring to build up custom by inducing manufacturers to employ tin-plate in place of other materials. As a rule these lines of consumption, which the mills have worked hard to build up, are the very ones that are now ruthlessly denied tin-plate, when the food products call for it, and are asked to find substitutes.

To stimulate the production of steel applicable to the filling of war orders the steel mills are indulging in many divergences from economical practice. They are using as scrap, material that has a high commercial value. For instance: Many mills are using sheet-bar crops as heavy-melting steel, when in the open market they would bring a price far above the heavy-melting steel basis. Shell-discard steel is being used in the same manner, when it could be rolled into finished products such as light rails, concrete reinforcing bars, bedstead angles and the like, at a very good profit. Valuable steel is thus used because the output of steel applicable to the filling of war orders is thereby stimulated. The case is not comparable with conditions in 1916 when with a large production of shell-steel mills were practically forced to melt a large part of their discard material.

Sacrifices of a new order are now being required, the authorities at Washington having begun instructing mills to close certain departments entirely so that supplies of war steel may be augmented. A notable instance of the early operations of this sort was the closing of the rolling departments of a new steel mill in the Cleveland district, the plant being asked to ship its entire ingot output to other plants which could use the crude steel in filling especially important war orders. The plant in question receives merely a price applicable to ingots and is deprived of the profit that would accrue from operating its rolls.

All these things are relative. With the greatest sacrifices that may be made by way of diverging from the most economical practice or the most profitable line of business, the steel mills have much larger earnings, even after the payment of Federal taxes, than have accrued in the best of peace times. That practice which might be denominated expensive are requisite is an argument that care should be exercised to maintain the set prices at such a level as to leave a safe margin. The profits, however, ought not to be permitted to be excessive unless it is intended to tax them still more heavily.

Readers' Views and Comments

The International Technical Affairs Information Service

To the Editor of Metallurgical & Chemical Engineering

SIR:—In spite of the greater efficiency of the individual American, the collective work of the Germans has been far greater in efficiency than the work of the Americans. I repeat, the *collective work was greater.*

The industrialists of this country have come to place more and more dependence upon information in print. To substantiate that statement it is only necessary to count the several hundred libraries operated by our leading industrial houses. The work of these several hundred industrial or technical libraries is extremely valuable, but these libraries, or the majority of these libraries, are working *independently.* The *collective work* of these libraries would aid the industrialist of this country and our allied countries tremendously.

France through the Societe de l'Encouragement pour l'Industrie Nationale, is pushing a national organization for a "technical literary reference bureau to aid the industrialist in the 'economic struggle' after the war." Belgium and Switzerland already have valuable establishments for the collecting and coördinating of scientific literary information.

America has recently formed, under the National Research Council, a Research Information Committee. The platform of this Committee was outlined in the April 1st issue of METALLURGICAL AND CHEMICAL ENGINEERING. In this Committee, so recently formed, there is, or might be, the beginning of a Directional Committee for the coördination of the resources to be found in the libraries of these several hundred industrial or technical libraries about the country, to say nothing of the valuable technical collections in the public, college and society libraries about our country and allied countries.

Believing that some sort of action is needed to follow up the excellent plea made in the editorial to be found in the March 25, 1915 issue of *Engineering News-Record* I have attempted to outline a few steps for the immediate organization of the "association of engineering librarians" called for in this editorial.

First, there should be appointed from the field of industrial libraries, a committee on coördination and coöperation. Second, this committee should earnestly study the most profitable ways of linking together these several hundred technical libraries. Third, the central office of this committee might well be allied with the central office of this newly formed Research Information Committee of the National Research Council, with a branch in all of the principal cities of this country and allied countries. Fourth, this organization should receive government recognition, as perhaps in no other way would certain of our close corporations be willing to open their facilities or unite with other facilities excepting under government orders. Fifth, a certain amount of government aid should be given this organization, as for example franking privileges, in certain operations and free distribution to this International Technical Affairs Information Service of its publications likely to be of value to this Service. Fifth and last, this International Technical Affairs Information Service should function, not only as a directional force in administering the coördinated resources, but it should also act as a large mail-order house of technical information for the industrial house not supporting a technical library.

Technical information is now being made, or put in print by the second. Every day lost in not harnessing this information through this proposed International Technical Affairs Information Service means so much economic loss to the many hundred technical men needing technical information as they never needed it before to say nothing of the excessive demand for technical information after the war. Why not organize this International Technical Affairs Information Service NOW?

K. C. WALKER.

Library, New Jersey Zinc Co.,
55 Wall St., New York City.

Rapid Carbon Determination

To the Editor of Metallurgical & Chemical Engineering

SIR:—The following method for determining the carbon in steel has been used by me with considerable success, in the past few months. Johnson's method is used. The gas is taken from a high-pressure tank through a regular high-pressure reducing combination valve, comprising the diaphragm valve, followed by a needle valve. Both of these valves are kept open during the entire time that the apparatus is in use. The diaphragm valve should be so adjusted that it will admit a maximum of 15 lb. pressure to the train. I believe that the normal setting of these valves is between 15 and 25 lb. Between the valve and the train is a "Y" tube, one branch of which leads to the train, the other to a "U" tube filled with mercury, capable of accommodating at least 20 lb. pressure. This furnishes the "head" for the operation of the train. The gas passes successively through stick caustic, strong caustic potash solution, soda lime and calcium chloride. These reagents are contained in four towers of about 7 in. in height by 1½ in. diameter, with a shoulder at the top, taking a number five, two-holed rubber stopper. The jar containing the caustic potash solution should have about ¼ in. of mercury in the bottom to act as a seal in case the rubber tubing between the purifying train and the tank should break. These jars must be of fairly heavy glass with solid bases. They are filled and interconnected so that they occupy a space about 7 in. square. The stoppers are kept tightly in place by setting the apparatus on an 8 in. square board, placing another board of the same size, suitably perforated, on top of the stoppers, and clamping all together with long bolts running from top to bottom. On top of the top board is placed a gas header containing, besides the inlet, three gas valves, preferably those with long handles, as they are easier to manipulate.

The furnace cases are made of 3½ in. seamless steel tubing 1 ft. long. The ends are of asbestos wood.

The combustion tube is of fused silica, and the resistance wire is wound directly thereon for a length of about 9 in. The combustion tube is then placed in the casing and after the leads are secured, quick lime is packed tightly into the case until full. This furnace is very quick to heat, and uses less current, and lasts longer, than when the wire is wound on a protecting tube of alundum or is covered with clay. Moreover, fused silica combustion tubes lose their vitreous character, after some months of continuous use and must be discarded anyway. The furnaces are suspended, side by side, by means of metal straps from two pieces of strap iron, 1 in. by ¼ in., one at either end. These pieces of strap iron are bent in the shape of a square cornered inverted U, and are of such size and height from the table that the openings at the furnaces are a little below the level of the eyes. From the furnaces the gas goes to three sets of zinc-phosphoric anhydride tubes, and from there to the regulation Johnson absorbing bulbs.

The samples are all weighed beforehand into small sheet-metal troughs, closed at one end. These are kept in numbered compartments in a closed box until ready to run. The boats are made of nichrome ribbon. 1 in. by 13 gauge, 3½ in. long. They are simply bent into shape without welding. They are easy to make, last almost indefinitely, and the pigs do not stick to them, unless lead oxide is used. In weighing the absorbing bulbs, weigh them all against a common tare. It is convenient to make all the tubes weigh about the same amount.

Exclusive of the time required to weigh the samples, the writer has repeatedly run ninety carbons in eight hours. Three tubes are used for each furnace; one running, one weighing and one standing. Results on plain carbon steels usually check in the third decimal place.

W. L. JACKSON.

E. C Atkins & Co.,
Indianapolis, Ind.

Special Gold-Recovery Processes Practiced by the Early Portuguese and Spaniards

To the Editor of Metallurgical & Chemical Engineering

SIR:—In an interesting and well-written book, now very rare, entitled "Travels in the Interior of Brazil," particularly in the Gold and Diamond Districts," written by John Mawe, an English scientist and engineer and author of the "Mineralogy of Derbyshire," published in Philadelphia and Boston, in 1816, is a metallurgical reference which may have some import to the intrepid writers who are so readily, but not too lucidly, explaining the theories of flotation. On page 194, Mr. Mawe, in describing the methods practiced in the gold placer districts of Minas Geraes, to recover the gold from the black sands obtained in the major placer operations, says: "Some of the grains of gold were so fine as to float on the surface, and of course, were liable to be washed away in these repeated changes of water; to prevent which the negroes (slaves) bruised a few handfuls of herbs on a stone, mixed the juice in small proportions with the water in their gamellas (pans). Whether this liquid did in reality tend to precipitate the gold, I could not positively ascertain, but the negroes certainly used it with the greatest confidence."

Perhaps some of the flotationists can explain whether this primitive metallurgical application involves any of the present day principles of "surface tension," "ionization," etc., etc., which are invoked in order to justify, after the fact, the marvelous results of flotation as a metallurgical practice. Apparently the early Brazilian process "worked," but I have no information of the continued or wider application of the principle involved. It would be interesting if the delvers in the archives of metallurgy can confirm this observation of Mr. Mawe's.

On the west coast of Mexico, some years ago, I had as my mozo (servant), a very old Mexican miner, who in harmony with his antiquity, still lighted his cigarette with a flint and steel. He told me that in his youth in the mountains of Sinaloa he had been engaged in a gold mining operation in which the gold was refractory and difficult to recover. As an accessory to the metallurgical appliances and processes of that early day, which are more or less well known, it had been found effective in the treatment of this particular ore to crush it in the tahones (Chilean mills) with the leaves of a certain tree, and then to filter the slimes and water from the mill through charcoal, which charcoal was afterwards burned and an appreciable amount of gold recovered thereby. The tree, as it was described, was a species of oak and it was suggested that the leaves might have yielded tannic acid, or some compound related to cyanide. Since the advent into the metallurgical world of flotation, the idea has occurred that possibly this metallurgical practice of the early Mexicans was a crude precursor of flotation.

Is it not possible that these two instances of primitive metallurgy represent the early application of differential and selective adhesion of special solutions somewhat similarly as in the modern flotation processes and their modifications?

KIRBY THOMAS.

New York, N. Y.

Influence of Temperature of Measurement on the Electrical Restivity and Thermo-Electromotive Potential of Solutes in Steels

To the Editor of Metallurgical & Chemical Engineering

SIR:—In your issue for November 15, last, you republished from a preprint of the American Electro-Chemical Society an article which I presented to that Society at its meeting in October. Your journal naturally reprinted it exactly as it appeared in the preprint, but proof of this article was never sent me before it appeared in the preprint. There were one or two minor mistakes in the title of the article, but these were not at all serious. There was, however, one serious mistake which arose from the fact that the printer in setting up the article omitted an entire line so that the meaning of the sentence was naturally lost. This sentence occurs near the top of the second column on page 592 of your journal. This sentence should read "would transform a maximum amount of electrical energy into heat, thus causing a maximum electrical resistivity."

E. D. CAMPBELL.

University of Michigan, Ann Arbor, Mich.

Western Metallurgical and Chemical Field

Conditions in Joplin-Picher Region

THE Joplin *News Herald* recently published interesting tables showing the production of blende, calamine and lead from the various camps in that region for the years 1916 and 1917. These tables furnish the basis of the following figures:

	Approximate Average Weekly Production of Blende for 1916	1917	Production for Week of Oct. 20, '17	Apr. 14, '18
Highest grade blende (basis 60% Zn)	...	.....	$75 per ton	$55 per ton
Price of zinc	...	...	7.9c.	7.0c.
Production:				
Oklahoma camps	2,080,000	5,920,000	8,463,000	7,323,890
Joplin	2,180,000	1,820,000	1,747,860	817,750
Webb City-Carterville	4,540,000	3,340,000	2,087,020	957,750
Duenweg	1,330,000	1,080,000	1,620,680	...
Total, including miscellaneous camps and calamine	14,150,000	15,700,000	18,205,210	12,701,760

The yearly figures show very plainly the rapid growth of the Oklahoma camps at the expense of the older fields; the Webb City—Carterville "sheet ground" district suffering the most. Many mills have been moved from the regions nearer Joplin to the richer Oklahoma camps, which have been able to continue much more nearly at its high rate, despite the low price of ore. The sheet ground mines are almost all down. From Duenweg to Oronogo there are only about a dozen mines and mills in operation where there were eighty a year ago.

Such conditions has provoked much discussion among the operators in the Tri-State field, resulting in resolutions calling for a tariff on imports of zinc ore amounting to two cents a pound. Their association has also appointed a committee to go to Washington in an attempt to interest the President directly in measures for their amelioration.

In the face of the rapid decline in the price of spelter occurring since the summer of 1917, the agreement between producers and the War Industries Board on a price for Grade A zinc brought a gleam of hope. This agreement was made in February under the usual stipulations as to uniform price, wages, production and speculation, and fixed 12 cents a pound for Grade A zinc, 14 cents a pound for plate zinc, and 15 cents a pound for sheet zinc thinner than $\frac{1}{2}$ inch. While the Joplin district produces but little of this material, still if the usual pre-war differential between sheet-zinc and prime western continued to exist, it would automatically place some sort of regulation on their product. Unfortunately this spread, which was 2.15 cents in August, 1914, has continued to widen, and the general zinc market has continued to slump.

The prospect of the government finding a larger use for that spelter which has hitherto been barred from Grade A owing to the presence of a little more cadmium than is permitted by the standard specifications has been carefully considered. It is not supposed that the specifications on Grade A will be lowered, but a higher cadmium zinc may be accepted on certain government work at a small discount from the Grade A price. If the smelters, on the other hand, could be induced to abandon the time-honored schedules, and pay an extra figure for cadmium-free ores, it is thought certain that considerable concentrates very low in lead, iron and cadmium could be selected and marketed for the production of Grade A. Meantime, with the increasing spread between prime western and higher grades, the margin available to cover redistillation costs becomes wider, but the resulting production of Grade A spelter affects the prosperity of the miner and millman but slightly.

The Pacific Kelp-Potash Industry

Several concerns are now engaged in the manufacture of potash from kelp on the southern Pacific coast, notably the Pacific Products Company, the Sea Products Company, and the Oceanic Engineering Corporation at Long Beach, the Lorned Manufacturing Company at Summerland, the Hercules Powder Company and the Swift Fertilizer Company at San Diego, California. The Bureau of Soils of the United States Department of Agriculture began the construction of an experimental plant for the extraction of potash from kelp last April at Summerland, California, and has operated since the latter part of August, under the direction of J. W. Turrentine.

The purpose of this plant is two-fold: To determine the cost of producing potash from kelp, but more especially to determine what byproducts can be simultaneously produced commercially. The product to date has been principally kelp char containing about 30 per cent K_2O, which has been produced incidentally in experimenting in methods for drying and distilling. This has found a ready sale at a very good price—practically paying the operating costs of the plant. There is of course a great demand for potash in the fertilizer and other industries, and for the iodine and other chemicals recovered as a by-product.

The plant has a capacity of about 150 tons per day, which can probably be increased to 200 tons after certain refinements in operation have been introduced. Apparatus is now being installed which will make possible the production of high-grade muriate and numerous byproducts. The present installation has cost approximately $100,000 and consists essentially of a self-propelled kelp harvester of a harvesting capacity of about 25 tons per hour, and a carrying capacity of 100 tons. The shore plant contains unloading devices and conveyors for delivering the kelp to storage bins, the latter of a capacity of about 300 tons; a drier house containing three direct-heat counter-current rotary kilns, 50 feet long by 5.5 feet in diameter, with furnaces; and the necessary vacuum evaporator, crystallizer and lixiviating apparatus.

Arizona Copper Company Increases Mill Capacity

During recent months, Mr. Arthur Crowfoot, mill superintendent for the Arizona Copper Company, has been able to increase the daily capacity of their mill at Morenci from 2800 to 4000 tons with virtually no important additions to the area of the plant. The increase has been effected by a revision of the flow sheet, necessitating the installation of two Symons disc crushers in the crushing division, the elimination of jigs, the installation of a new floor of tables, and the construction of additional large settling tanks. The last item of construction has just been completed, and includes very large Dorr thickeners for dewatering the tailings as well as the concentrates. This practice is necessary in order to conserve as much water as possible—fresh water is

pumped a distance of about six miles against a considerable head. Since it requires approximately 450 gallons of fresh water per ton of ore concentrated in order to sluice the tailings down the canon to their disposal, at least that amount of water must be added to the mill heads. A very interesting design of water meter after the order of the tilting tank washer has been installed in the concrete reservoir acting as a supply tank for the operations of the concentrator.

A particularly noteworthy feature of the concentrator is the installation of a dust-catching system in the crusher division. Gyratory, disc crushers and rolls for reducing 4000 tons of mine run to ¾-inch size are housed in and connected to an exhaust fan, which delivers the dusty air to a centrifugal dust catcher. The solids are sprayed with water while circulating through the catcher, and the separation is so nearly complete that little dust can be observed in the exhaust. The atmosphere in the crushing division itself is very clear, and the installation may be said to have solved the dust problem in the dry-crushing plant.

A 100-ton experimental mill is being installed in a building formerly used as a crushing plant before the new main hoisting shaft was sunk. In this plant methods will be studied of concentrating low-grade sulphides containing in the neighborhood of one per cent copper, which the company possesses in very large quantity. The first trials will be on floating the finely-ground eject from a Marcy mill, with table cleaning of the flotation tailing.

Portland Company Closes Colorado Springs Plant

The exhaustion of bonanza mines is often referred to as the reason why a large expansion in metallic production does not follow war prices. Unfortunately gold production is hindered rather than helped by high prices, but the continuing exhaustion of known deposits is as patent as those of other metals. Witness the closing of the Colorado Springs plant of the Portland Gold Mining Company, of which a final clean-up was made in April. This mill was built to treat high-grade ores only, and is useless now that the high-grade ores of the Cripple Creek District are being exhausted. In its sixteen years of life it has extracted gold at an average rate of over two million dollars per year, but during the past years there has been a constant decrease in the tonnage of high-grade ore shipped, owing to a lessened production of the district, this doubtless accentuated by the shortage of efficient labor and the high cost of fuel, powder, timber, and other necessary supplies.

The Portland Company foresaw the probable shutdown of the Colorado Springs plant and provided room for the treatment of their own and custom high-grade ore when constructing their new Independence Mill, expecting to transfer the necessary machinery and workmen from the older plant. The Independence Mill, by the way, was primarily designed to treat monthly about 42,000 tons of low-grade ore from dumps and old workings, the latter estimated to amount to about three million tons. Eventually all milling-operations of the Portland Company will doubtless be done at this new mill, which is modern in every respect, since the Victor Mill, built eight years ago as an experimental plant to handle ores too low in grade to bear shipment, was constructed at the mine on an unfavorable location. It has earned net profits more than double its original cost, however, while the net earnings of the Colorado Springs plant amount to several times the original cost of that plant.

By-Product Coke Plant at Pueblo

Two batteries, each of 60 Koppers ovens, are nearly completed at the Minnequa plant of the Colorado Fuel and Iron Company at Pueblo, Colo., and have the distinction of being the first of their kind west of St. Louis. The operations of the by-product coke department will be in charge of H. B. Carpenter as superintendent. The ovens are of the regenerative type, with vertical flues, and are 40 feet long, 10 feet high, and 19 inches wide, with a capacity of 12½ tons of coal, which charge produces 8½ tons of 16-hour coke. This installation can therefore carbonize 70,000 tons of washed Trinidad coal per month, making 46,000 tons of coke and distributing daily 600,000 cubic feet of by-product gas at a pressure of five pounds per square inch to the open-hearth department, heating furnaces and soaking pits.

The hot coke will be pushed into a transfer car, taken to a brick quenching station and drenched by a large spray of water, and thence to a coke wharf, down which it slides. A rotary feeder then delivers it to a 42-inch conveyor leading to a screening station; the large coke goes to the blast furnaces, and the breeze and dust are burned in Cox stokers under steam boilers.

Tar from the primary coolers, gas mains and tar extractors is separated from ammonia liquor in a tank by specific gravity, and loaded into tank cars for shipment. A complete plant for the recovery of by-products from the oven gas has been installed. Ammonium sulphate, benzol, toluol, xylol, solvent naphtha and naphthalene will thus be separated and purified for the market.

New Picric Acid Plants

Contracts have just been completed by the Ordnance Department for the establishment of two large picric acid plants. Sites have been selected at Little Rock, Arkansas, and Brunswick, Georgia, and the construction work will be rushed at once by the contractors. Men and material for the buildings are all ready on the ground at Little Rock, and it is expected that the plant will be in operation by September.

The Everly M. Davis Chemical Corporation has been awarded the contract for the Little Rock plant, the construction of which will cost approximately $1,000,000.00.

A larger plant is to be constructed by the Butterworth-Judson Co., of New York City, at Brunswick at a cost of nearly $7,000,000.

These are the first government-controlled picric acid plants to be established in this country. The sites were chosen in the South after a most careful investigation of housing, labor, transportation facilities, and strategical conditions. In choosing the Little Rock location, the Ordnance Bureau was able to take over a number of buildings which will be used as part of the plant.

The location of these plants in the South, in addition to the two nitrate plants now located at Sheffield, Alabama, makes that section of our country preëminent in the manufacture of chemicals by the Government for production of explosives.

Water Power Hearings Closed

Joint Water Power Committee of Congress Begins to Draft Bill

THE record of the special hearings held on water-power development was closed May 18 after listening to the news of Secretaries Baker and Houston, who, with Secretary Lane, comprise the commission proposed in the Administration bill. A formal statement by William H. Onken, Jr., editor of *Electrical World* was submitted and added to the record.

Statement of Secretary of War Baker

Secretary Baker commented on the bill as originally submitted by the three secretaries and also on the effect of the proposed amendments subsequently offered. The latter he said were introduced for the purpose of clarity. His own view is that the terms of the franchises provided for in the "administration" water-power bill shall be definitely limited to fifty years. On this point his testimony was as follows:

"We have to decide at the outset whether a fixed term is to be used, at the end of which there is an end of the rights of the licensee, or whether we are going to spread the investment of any licensee over an indefinitely prolonged period under proper safeguards. If it be determined that a single term of fifty years is to be the principle of the bill, then any investor must, whether you provide it in the bill or not, amortize the investment in fifty years. That means that the consumers during the fifty years will have to pay by that much a higher rate than they would have to pay if they covered in their rates merely obsolescence and replacements and did not sink the entire original cost during the period of the grant. If the primary object is to secure a minimum rate to the consumer, the course of having consecutive terms would be the proper course.

"The purpose of this bill was to have a fifty-year term, and at the end of the fifty-year term the government was to have the three options of either taking over the property, granting it to a new licensee or regranting it to the original licensee or his successors in interest. The intention of the bill was to make those three options identical, so far as the financial obligation was concerned. If the government took it over, it would pay X dollars; if it granted it to a new licensee, the new licensee would pay X dollars; if it regranted it to the original licensee, it would ascertain and fix, as a new starting point for his net investment, X dollars, the same number of dollars in each instance. The purpose of the bill, as originally drawn, I think—and certainly as clearly shown by the amendment—was not to sink and amortize the original cost during the first term, but to carry that investment—depreciate it so that at any particular period of renewal it represented the actual value—to carry that forward as a continuing asset in the licensee, either to be repaid to him by any other licensee or by the government or to be regarded as his investment at the beginning of the new license period.

Secretary Baker Favors Fifty-Year Term Without Privilege of Renewal

"Now, my own judgment, my very strong preference, is for the first of those courses, to fix an absolute term and to allow the government not to have a system of equities built up against it at the end of that term. If that were done, it would cost more to the consumer clearly, but if it is intended to do that, it ought to be so clearly done that when the first term or first license does expire, there will not be any doubt that the government has a right to expect the licensee to have protected himself by amortization during the period.

What Constitutes Fair Value

Secretary of Agriculture Houston, in discussing net investment as defined in the amended measure, said that the original draft of the bill provided for recapture of the water power development at fair value. In suggesting the term "net investment" as the basis for payment it was thought it would not be susceptible to any misunderstanding or misinterpretation inasmuch as the term was specifically defined. However, it is inconceivable that there should be any unappropriated surplus to deduct from the original cost as required in the measure (see *Electrical World*, March 16, page 581), and for that reason he suggested the following amendment to the clause on "net investment" as defined in the amended measure or to "fair value" as understood in the original draft:

"That out of surplus earnings, if any, accumulated in excess of a specified rate of return upon the net investment of the licensee in any project or projects under license the licensee shall establish and maintain amortization reserves, which reserves shall, in the discretion of the commission, be held until the termination of the license or be applied from time to time in reduction of the net investment. Such specified rate of return and the proportion of such surplus earnings to be paid into and held in such reserves shall be set forth in the license."

Should the government at the end of the fifty-year period take over the project that sum would be deducted from the original cost. Whether or not to make amortization within the fifty-year period compulsory was a question of policy for the committee to decide. To do so would mean higher rates for the electric service during the life of the franchise, which the utility has a perfect right to exact.

Statement of William H. Onken, Jr.

The question of waterpower development has been so fully discussed before various congressional committees during the past six years that it is difficult to contribute anything new to the voluminous testimony already forming part of the record. However, it may be pertinent to observe that notwithstanding all the light that Congress has received on the subject, we still lack legislation due to the failure of legislators themselves to agree.

In view of the fact that electricity is now more and more a necessary part of our social and industrial life, and that its uses for purposes of irrigation and for the manufacture of nitrogen for explosives has become a matter of trmendous import in our national defense, might it not be well to abandon all theories of ideal legislation and adopt some practical measure as speedily as possible?

The Value of Cheap Electricity to Industry

As typifying what hydroelectric development means to a community and at the same time showing the enormous waste caused by non-development, the case of Niagara Falls is unique. The mighty cataract alone, not including the rapids is capable of developing five million horsepower. This, if sold at the modest rate of twenty dollars a horsepower, or what is equivalent to 3 mills per kilowatt-hour would yield a revenue of one hundred million dollars per annum. This amount of money is qual to a 5 per cent return on an investment of two billion dollars, and yet what government would spend that stupendous amount of money to reproduce the spectacle? It is true, we have power companies which develop a fraction of the power available, but the roar of Niagara is as nothing compared to the din of the industries set in motion by the electricity generated from a fraction of the water in the falls.

At Niagara Falls are located the greatest electrochemical industries of the world. More would be located there if more power were available but because of the shortage of power many have been forced over into Canada, and still others have gone abroad. These electrochemical industries are of vast importance to this nation. They started at Niagara Falls and for the greater part they still remain, handicapped as they are for want of electricity. On these electrochemical industries depend numerous other industrial establishments throughout the country, valuable in time of peace, but infinitely more valuable in times of war.

First of the electrochemical enterprises in point of electric power requirements is the aluminium industry. Next in line come the ferroalloy compounds including ferrosilicon, ferrochromium, ferromolybdenum and so on. The next electrochemical industry in point of size is devoted to the manufacture of calcium carbide used chiefly in the production of acetylene. Artificial abrasives which constitute the basis of all modern grinder work are also manufactured at Niagara Falls, as well as caustic soda, chlorine in the form of bleaching powder and other chlorine products; chlorates which are used in the match industry, in the textiles, for the manufacture of oxygen and in other chemical operations; sodium used in the textile industries as a bleaching agent, and which is still more important in the manufacture of sodium cyanide; phosphorus, carbon disulphide and numerous other products absolutely indispensable to industry today.

More Value in Industries Created than in Water Power

It is needless for me to continue further along this line to impress you with the vast importance of electrochemical products to other industries, ignoring entirely the fixation of atmospheric nitrogen for fertilizer and for munition work. I merely cite the case to show how infinitely more important are the industries depending upon electricity than the electric generating system itself. It is of interest to note in this connection that the combined income from the sale of electrical energy of the Niagara Falls Power Company and the Canadian Niagara Power Company for 1917 was a trifle over $3,000,000. I have no statistics showing the output of electrochemical products manufactured from the electricity sold for that purpose nor the cost of the numerous other products which in their fabrication involve electrochemical products. However, the citations given indicate the stupendous value of these products as compared with the cost of the electricity used.

Annual Meeting of the American Society For Testing Materials

The twenty-first annual meeting of the American Society for Testing Materials will be held at Atlantic City June 25 to 28, 1918, with headquarters at the Hotel Traymore.

A provisional program has been announced as follows:

Tuesday morning, June 25.
- Minutes of the 20th annual meeting.
- Annual report of the Executive Committee.
- Reports of technical committees.
- Announcement of election of officers.
- Miscellaneous business.

Tuesday afternoon, June 25.
- Reports of committees on wrought iron, cast iron, and testing.
- A Simple Type of Brinell Testing Machine for 500 kg. Load. A. V. de Forest.
- A New Type of Brinell Machine. J. G. Ayers, Jr.
- Effect of Moisture on the Strength of Aircraft Fabrics. G. B. Havens.
- Transverse Testing under Non-Uniformly Distributed Load as Applied to Airplane Wing Ribs. I. H. Cowdrey.
- Sumner Elastic-Limit Recorder. J. L. Jones and C. H. Marshall.

Tuesday evening, June 25.
- Annual address by the President, followed by a reception.

Wednesday morning, June 26.
- Reports of committees on steel.
- Cast Steel Anchor Chain. James French.
- Grain Growth of Cold Wrought Metals. D. J. McAdam, Jr.
- Changes within the Critical Range of a Given Steel: From Ac_1 to Ac_3. J. G. Ayers, Jr.

Wednesday evening, June 26.
- Topical discussion on coöperation in industrial research, by Dr. Henry M. Howe, Dr. John Johnston, Dr. A. D. Little, Dr. Charles L. Reese and Mr. Frank E. Gorrell.

Thursday morning, June 27.
- Reports of committees on preservative coastings and non-ferrous metals.
- The Valuation of Zinc Dust and a Proposed Method of Analysis. L. A. Wilson.
- Topical Discussion on "Season and Corrosion Cracking of Brass: Its Prevention and Means for Testing the Tendency Thereto."

Thursday evening, June 27.
- Joint session with the American Concrete Institute on cement and concrete.
- Reports of committees and papers on cement and concrete.

Friday morning, June 28.
- Reports of committees on lubricants and lime.
- The Standard Saybolt Universal Viscosimeter. W. H. Herschel.
- Internal-Combustion Engine: Lubrication and Lubricants. P. H. Conradson.
- The Variable-Pressure Method of Determining the Viscosity of Oils. E. C. Bingham.
- Mechanical Sifting of Cement. D. A. Abrams.
- Effects of Grading of Sands and Consistency of Mix upon the Strength of Plain and Reinforced Concrete. L. N. Edwards.

Friday afternoon, June 28.
- Reports of committees on ceramics and refractories.
- The Necessity for Inspection and Testing of Refractory Brick. C. E. Nesbitt and M. L. Bell.
- Silica Cement. R. J. Montgomery.
- An Abrasion Test for Gravel and Stone for Road Purposes. H. H. Scofield.
- Sampling of Deposits of Road Stone and Gravel. L. Reinecke.

Friday evening, June 28.
- Reports of committees on fireproofing, coke, waterproofing, electrical insulating materials, shipping containers, and rubber products.

Minerals Separation vs. Butte & Superior

Opinion of District Court in Favor of Plaintiff Reversed by Court of Appeals—Contentions Repudiated Regarding Non-Effective Oils—Minerals Separation Process Not Infringed by Use of More Than One Per Cent Oil

ON MAY 13, 1918, the United States Court of Appeals for the Ninth Circuit, at San Francisco, filed its opinion in the Minerls Separation-Butte and Superior Case.

Each of the judges wrote an opinion, Judge Ross and Judge Hunt, in concurrence, giving the majority opinion, while Judge Morrow wrote an opinion concurring in part and dissenting in part.

The opinions were rendered in a review of the decision of Judge Bourquin, of the District Court of Montana, which was given Aug. 25, 1917, and from which the defendant, the Butte and Superior, appealed.

Judge Bourquin's opinion, it will be recalled[1], was very strongly in favor of the contentions of Minerals Separation, and as Mr. Canby pointed out in his comprehensive review of the American litigation up to that time[2], Judge Bourquin's opinion practically reëstablished the original claim 12, so wide a scope did he allow Patent 835,120. He found that the defendant, in increasing its use of "oil" to an excess of one per cent, had done so by the use of certain oils which Judge Bourquin said were inert and useless, or even harmful, "having no more effect than so much milk or other useless substance," while maintaining the pine oil at about the same quantity which they had been using prior to Jan. 7, 1917, the date of the U. S. Supreme Court decision. Judge Bourquin thus discriminated between what he considered effective and non-effective oils, and decided that the defendant could not escape infringement by the addition of the latter.

In the presentation before the San Francisco Court the experts for Minerals Separation, among others, performed an experiment by way of demonstration to show that these petroleum oils which defendant was using were not frothing oil and would not produce a "froth." But unfortunately for their contention, and in absolute contradiction to the statements being coincidentally read from record by plaintiff's counsel, a really excellent froth was produced, so that the judges must have been more impressed by what they saw than by what they heard, since all three of the judges repudiated this distinction as to effective and non-effective oils.

Using More Than Fraction of One Per Cent of Oil Is Not Infringement

Even Judge Morrow, whose opinion is the dissenting opinion of the Court, says—"I am of opinion that the use of an oil or oily liquid in defendant's separation process in a quantity *not* 'amounting to more than a fraction of one per cent on the ore' is within the express terms of Claims 1, 2, 3, and 12 of plaintiff's patent, and is an infringement of such patent. But I am of the opinion that the use of an oil or oily liquid amounting to more than a fraction of one per cent on the ore is not within the terms of Claims 1, 2, 3, and 12 and is therefore not an infringement upon plaintiff's process . . . ."

We have been so long accustomed to think of the Minerals Separation patent (835,120) as being the use of one per cent of oil, that possibly few of us realize just what the patent really does mean, as decided by the U. S. Supreme Court and now interpreted by the Court of Appeals in San Francisco as its meaning, and that is that "a fraction of one per cent" does not mean every fraction of one per cent, but only that fraction of one per cent constituting "critical proportions."

Since the claims of a patent can not be broader than the discovery or invention it would seem clear that the claims of this patent, 835,120, referring to "a fraction of one per cent" should not be so broadened as to include a greater percentage than that embraced in this discovery. If this is so, Minerals Separation's exhibit of Higgins' report of the experiments as to the effect of reducing "oil" in the Cattermole process, clearly shows that it was at about half of one per cent that the effect constituting the discovery, was first apparent.

What Constituted Invention in M. S. Process?

In the argument before the U. S. Supreme Court there took place a colloquy between Justices McReynolds and Pitney, and counsel for Minerals Separation, which Judge Ross quotes in full, and to which Judge Hunt refers in these words:

> Again, when counsel had a colloquy (quoted in the opinion of Judge Ross) with the Supreme Court, the guiding thought evident in the mind of the inquiring Justices was to stamp precision upon the point when *invention in the process* began to appear. With apparent definite purpose of meeting the interrogatories plaintiff told the court that "invention" began to come when in the descending uses of percentages of oil as small quantity as five-tenths of one per cent was used, and was first present when three-tenths and two-tenths of one per cent was used. Of course a court should cautiously consider a response often quickly made by counsel in answer to questions put from the bench lest an injustice may follow by attaching undue weight to an isolated argumentative answer, but in this matter we are earnestly trying to gather the scope and accurate meaning of the expressed thought of the court. We may therefore refer to the fact that the exact position of the plaintiff as to the invention was called for not once but twice, not generally nor indirectly, but positively, simply and unequivocally.

The colloquy above referred to has appeared in journals reporting the proceedings before the Court, so that we need not quote it again from Judge Ross's opinion, of which it forms an important part, and although one can well imagine the chagrin of counsel in having such a colloquy forming so large a part of the Court's opinion, that is as to space occupied, and as shown in the above quotation from Judge Hunt's opinion, as to its determining force in interpreting the opinion which the U. S. Supreme Court intended to express, and, also, undoubtedly in determining the opinion of the U. S. Supreme Court itself, through the information which the colloquy gave to them, the actual fact as to the scope which the claims to Patent 835,120 would be entitled is in reality determined by the plaintiff's statement of the discovery as set forth in the Higgins' report, above referred to. One can not but assume that the U. S. Supreme Court, even without such a colloquy, would have decided as it has done, and that it was indeed such an appreciation of the scope of the discovery which led the Justices to make the inquiries.

[1]Met. & Chem. Eng., Sept. 15, 1917.
[2]Eng. & Min. Jnl., Dec. 1, 1917.

Three Points at Issue

Notwithstanding the very voluminous record in the case, and the many angles presented through the several hearings in the various cases up to this hearing, there was presented to the court in San Francisco practically only three points for decision. These were as follows:

First. What had the Supreme Court decided as to the bounds of the invention, and does the use of oil in proportions greater than the so-called "critical proportions" violate any rights of the patentee?

Second. Does the evidence in the Butte and Superior case contain anything which was not before the Supreme Court, of such a nature that that Court would have been led to a different conclusion if it had been presented in the Hyde case?

Third. What is the purpose and effect of the so-called "disclaimer" filed by the plaintiffs after the opinion of the Supreme Court in the Hyde case was handed down?

As to the first of these, Judges Ross and Hunt are of the opinion that the Supreme Court meant what they said as to "critical proportions" and that they did not mean that Claims 1, 2, 3, and 12 included all percentages of "oil" up to one per cent. "A fraction is one thing, every fraction is a different thing," says Judge Ross, and continuing, adds: "It is obvious, we think, that if the Supreme Court had meant to extend the scope of claims * * * of the patent to one per cent of oil on the ore as is here contended it would not have said anything about any fraction of one per cent. Certainly there would have been no necessity for doing so and certainly the use of such specific language as it employed without a purpose cannot be justly imputed to that great tribunal." Then after copious quotations from the decision of the Supreme Court, in the Hyde case, Judge Ross continues: "Nothing, it seem to us, can be clearer from the foregoing quotations from the opinion of the Supreme Court, than that it did not intend to extend the monopoly of the patent in suit to the use of one per cent of oil on the ore; for it, in effect, thereby distinctly declares and adjudges that the discovery of appellee "experimenters" only rose to the dignity of *invention* when they ascertained that the desired results could be and were obtained by the use of five-tenths (½) of one per cent of oil on the ore."

As to the second of the three points, above referred to, had they found sufficient new evidence to warrant them in so doing, they might have gone outside of the Supreme Court decision, even to the extent of finding the process of the patent anticipated, but this they did not do.

As to the third point, that is purely a legal technicality as to certain alleged undue delays in entering disclaimers as to the claims which were declared to be invalid by the Supreme Court, in the Hyde case, those claims in the patent calling for simply "a small quantity" of oil. The Court of Appeals found that there had been no illegal delay.

"The decree appealed from (in the District Court) must be and is reversed and the case remanded with directions to the Court below to so modify its decree as to accord with the opinions of the majority of this Court, the appellant to recover its costs on this appeal."

Annual Meeting of the New York Section American Institute of Mining Engineers

Symposium on the World's Iron Ore Resources—Election of Officers

THE annual meeting of the New York section of the A.I.M.E. was held in New York, May 28, 1918. Minor changes were made in the by-laws and the following officers were elected for 1918: Chairman, A. H. Rogers; vice-chairmen, Forest Rutherford, H. C. Parmelee; treasurer, Frederick T. Rubidge; members of executive committee, J. E. Johnson, Jr., and P. G. Spilsbury.

The meeting was a symposium on the iron ore resources of the world in relation to national economic conditions after the war. E. C. Harder, Waldemar Lindgren, C. M. Weld, A. C. Spencer, H. Foster-Bain and Sidney Paige each addressed the members present on different phases of the subject.

The Brazilian Iron Situation

E. C. Harder of the University of Minnesota presented a paper on the Brazilian iron situation.

He stated that Brazilian iron ores would now be offered in European and American markets had not the necessary capital been diverted for war purposes. It is considered equally certain that they will be a prominent factor in the reconstruction of Europe. The Brazilian iron-ore field takes rank among the five great iron-ore districts of the world, the others being (1) the Lake Superior district of the United States, (2) the Lorraine ore field of northern France and Southern Germany, (3) the northern Sweden deposits and (4) the ore fields of Oriente, Cuba. The Brazilian field is the greatest known undeveloped iron-ore district in the world, and its aggregate tonnage is variously estimated up to three billion and a half. The largest deposit contains at least five hundred million tons, and deposits containing from ten to fifty million tons are numerous.

The iron-ore district is about 100 miles square and is in the State of Minas Geraes, its center being about 250 miles north of Rio de Janeiro, with which city it is connected by the Central of Brazil Ry. A new railroad, the Victoria a' Minas, designed for ore transportation, is now under construction from Victoria.

Two types of ore occur. The more important interbedded variety gives a high-grade hard ore averaging 69 per cent iron, low silica, and less than 0.02 per cent phosphorus, and a low-grade soft ore averaging 60 to 68 per cent iron, depending upon the amount of silica, and from 0.01 to 0.07 per cent phosphorus. The other type is a product of weathering and is of lower grade but ranges up to 65 per cent iron and a phosphorus content of from 0.1 to 0.3 per cent.

Previous to 1910 practically all these deposits had been owned by Brazilians, but soon after that they gained publicity and were rapidly acquired by English, American, French and German interests. The English and American holdings are more important and include practically all of the deposits which will derive benefit from the new railroad. The German and French interests are tributary to the old railroad, which is scarcely able to handle its present manganese business.

It is still questionable as to just what use these ores will be put. Brazil itself does not at present offer a market and possesses no coal deposits suitable for iron manufacture. This lack of coal has been the great factor in retarding the development of the iron deposits; it necessitates exporting this great national resource of Brazil, which fact has caused the Brazilian government much concern but is now accepted as inevitable.

England has imported annually during the last few years about 4,500,000 tons of iron ore from Spain, about 1,000,000 tons from northern Africa and about 800,000 tons from Scandinavia. It is hoped that the Brazilian output may eventually reach 10,000,000 tons annually which will be sufficient to supply England's demands for foreign ores and leave a surplus for the United States and for other countries.

In the United States the Brazilian ores will probably be found to be a very desirable furnace mixture for low-grade ores and for more refractory ores. They will doubtless also be used in the Bessemer furnaces to replace the gradually decreasing supply of domestic Bessemer ores.

The great fleet that will be necessary to carry the iron ore to the United States and Europe will be used to carry return cargoes to Brazil. This will offer cheap transportation for such products as coal, iron and steel manufactured articles and cement. It will aid greatly in the industrial development of the country and perhaps eventually it may be possible to operate small iron and steel plants in Brazil at a profit to supply the domestic needs of iron and steel products.

Swedish Iron Ore Reserves

Dr. Lindgren discussed the Swedish and Norwegian iron-ore deposits. He stated that the deposits in the central part of Sweden were divided into three groups. The first group consisted of high-grade magnetites imbedded as lenses in limestones and dolomites. There are small quantities of these ores and they are of no importance for export. They are used in Sweden in the production of high-grade iron. Associated with the magnetites are banded hematites which are also of only local interest. The apatite iron ores of central Sweden are of importance as the reserves amount to 100,000,000 tons and a considerable exportation of them is carried on. The total reserves of central Sweden amount to 122,000,000 metric tons. These deposits are of minor importance to the world as a whole.

The Lapland deposits in northern Sweden at Gellivara and vicinity were stated to be of the greatest importance as the ore reserves totalled 1,150,000,000 metric tons and are concentrated in a comparatively few large deposits. The iron ores are rich in phosphorus, only a small proportion being as low as 0.05 per cent phosphorus. The bulk of the ores average 58 per cent iron and from 1.5 to 3 per cent phosphorus. The deposits are opened by a railroad which extends from the Baltic to the Arctic ocean, and, while the severe climatic conditions interfere with operations, a production of 7,000,000 tons per annum was made according to the last reports. Under pre-war conditions one-third of this ore was shipped to England and two-thirds to Germany. The iron ores of Norway are of less importance and total 280,000,000 metric tons. As much of this ore is low grade its exploitation is dependent upon the success of concentration methods.

Importance of Cuban Iron Ore

A description of the Cuban iron ore deposits was given by C. M. Weld. He estimated the total tonnage at 3,000,000 tons. They form surface blankets of great extent, averaging from 15 to 25 ft. thick and ranging from 1 to 70 ft. in thickness. There is no overburden. The ore is high in hygroscopic and combined water, the total of water reaching 35 per cent. The phosphorus content is below 0.02 per cent and the ores contain 0.5 to 1 per cent nickel and 1.5 per cent chromium. The steel made from the ore has valuable properties. The deposits are of first importance.

The Iron Ores of China

The iron ore deposits of China were briefly reviewed by H. Foster Bain, of the U. S. Bureau of Mines. Mr. Bain said that while it is still too early to make complete estimates of China's resources enough is known to warrant approximate figures. Stated in the briefest terms the approximate probable tonnage of the known deposits suitable for modern uses is 402,000,000. Of this the Chinese government retains title to about one-third, Chinese companies claim somewhat less than one-third, and Japanese or Sino-Japanese companies have over one-third. These estimates do not include all of the iron ore as doubtless there are deposits still to be discovered and in the smaller bodies suitable only for native furnaces or far in the interiors there is not improbably 300,000,000 tons additional.

Mr. Spencer gave the following figures for the reserves of Europe and Africa in metric tons:

Continental France, not including Alsace-Lorraine, 2,000,000,000; Spain and Portugal, 730,000,000; Austro-Hungary, 200,000,000 to 300,000,000; Greece, 100,000,000. Algeria, 150,000,000.

Fixed Price for Toluol

The War Industries Board has had its attention called to the fact that in some instances excessive prices are now being demanded for toluol when sold under release for other than military purposes.

When Government action or demands in any branch of trade results in material increase in price, it is incumbent upon the Government to protect other users of the commodity by seeing that the price to the trade does not advance to a point in excess of the price paid by the Government.

In accordance with this the War Industries Board has extended the Government price to cover all toluol which will be released for non-military purposes.

The Government price is:

Carload lots in tank cars.....$1.50 per gallon
Any quantity in drums.....$1.55 per gallon

No release will be granted for shipment of toluol where a price in excess of the above is asked and all releases granted for other than military uses will be stamped:

"Released only upon condition that price does not exceed $1.50 per gallon in tank cars; $1.55 in drums."

The War Industries Board will be glad to have its attention directed to any demand for higher prices.

The President's Readjustment and Reconstruction Commission

A Vital Suggestion Relating to the Establishment of American Industry on a Sound Basis After the War—What Foreign Countries Are Doing—Necessity for Taking Care of Our Present Industrial Expansion

BY WINGROVE BATHON,
Washington Representative, McGraw-Hill Co., Inc.

PEACE will come some day. In the meanwhile American industry is doing nothing whatever in an organized way to prepare for the necessary readjustment. On the other hand, England and her colonies, France, Italy, the Teutonic empires, the Far Eastern countries, and the Latin-American countries have begun to prepare for readjustment and reconstruction.

What must we do?

This article is for the purpose of suggesting the immediate creation of an agency to deal with the situation which will confront American industry at the end of the war, to gather facts now, to make plans now, to educate now, and to lead the industries of the country in the victories of peace when the right time comes.

In detail, this is to suggest that a great service would be done the American people, and perhaps all of the free peoples of the world, in view of the resources of the United States which must be drawn upon for a long period by the whole world after the war, if the President of the United States would appoint forthwith a commission, to be the President's own commission, to prepare for after-the-war problems. Such a commission should not be hampered by legislative enactments of Congress as to powers upon which it might be difficult for Congress to agree; not curbed and controlled by Government appropriations or the fear of lack of them. It should nevertheless be established under the Government sanction of an executive order, and should be assisted by the creation of an Advisory Council of Government officials and possibly the chairman of some committees of Congress. Many executive officials and legislators are themselves too busy with the work of the war to lay aside burdens of today to deal with after-the-war problems. Their assistants and associates should be used. As to the main commission, it should include not only leaders in industry of all forms taken from the ranks of private endeavor, but it should include leaders in labor, leaders in education, and leaders in every other endeavor which enters into industrial effort. Such a commission should report only to the President and should take as much of its inspiration from his leadership as he has time to give from the conduct of the war with which he is charged by the Constitution. Such a commission might very well include in its appointees the following:

Suggested Personnel of the Commission

E. H. Gary, President of the American Iron and Steel Institute; Samuel Gompers, President of the American Federation of Labor; Arthur N. Talbot, President of the American Society of Civil Engineers; C. P. Main, President of the American Society of Mechanical Engineers; E. W. Rice, President of the American Institute of Electrical Engineers; Sidney J. Jennings, President of the American Institute of Mining Engineers; Wm. H. Nicholls, President of the American Chemical Society; F. J. Tone, President of the American Electrochemical Society; A. G. Doan, President of the American Machine Tool Builders' Association; H. A. Wheeler, President of the Chamber of Commerce of the United States; P. H. Gadsden, Secretary of the American Electric Railway Association and Resident Washington Member of the Electric Railway War Board; S. G. Williams, President of the Highway Industries Association.

In addition there should be the presidents of some of the various national organizations occupied with production and manufacture in the lumber, leather, rubber, textile, glass and other great industries of the country; as well as perhaps the president of the Farmers' Grange, the president of a great railroad, the president of a great shipping company, the president of a great educational institution, the president of a great insurance institution, and perhaps the president of the American Bar Association and the president of the American Medical Association; but, in any case, and by all means, even if only to assure reports from abroad, the following representatives of American business in other countries:

A. V. Edwards, Secretary of the American Commercial Club of Argentina, Buenos Aires; Charles E. Lydecker, Secretary of the American Chamber of Commerce of Brazil, Rio de Janeiro; James R. Morse, Secretary of the American Chamber of Commerce in China, Shanghai; George M. Cassatt, Secretary of the American Chamber of Commerce in England, London; Charles H. Sherrill, Secretary of the American Chamber of Commerce in Paris, France; J. B. Stetson, Jr., Secretary of the American Chamber of Commerce in Italy, Milan; C. B. Parker, Secretary of the American Chamber of Commerce for Mexico, Mexico City; Preston M. Smith, Secretary of the American Chamber of Commerce for Spain, Barcelona; and Theodore R. Yangco, Secretary of the Chamber of Commerce of the Philippine Islands, Manila.

In Washington, the peace-time industries of the country are now being placed upon a war basis in a gradual manner. There has been time for a gradual "turning over" in the further organization of the war which has been proceeding steadily month by month. But when the industries of the country have been fully

placed upon a war-time basis, when supplies of labor, sources of material, reserves of capital and the markets for production have all been altered to meet war needs, it will be impossible to place industry back upon a peace basis gradually without danger of disaster second only in importance perhaps to the actual loss of the war.

To meet the danger there must be organized preparation, such as is now proceeding in all of the countries at war except the United States, and these suggestions are being made to set forth a working plan as a nucleus for discussion and action.

Similar Work Done by Foreign Countries

The facts and the prospects for the future are being discussed and acted upon in almost every country of the world except this. Literally thousands of books, pamphlets and other writings have been produced in foreign countries to educate the people along these lines. More than two years ago there was created in Great Britain a Reconstruction Committee, which has since become an agency of the British Government, the work now being in charge of Dr. Christopher Addison, a Minister in the British Cabinet without portfolio; and more than two hundred sub-committees plentifully supplied with experts are now engaged in solving British after-the-war problems.

The detail of what has been done in Great Britain and the other countries previously mentioned, and some suggestions as to what should be done toward readjustment in this country, will be offered in later articles.

After the war, because of accelerated thinking, we can secure the adoption of ideas that otherwise would not be acceptable, or would be acceptable only after a very lengthy educational process. Therefore we have an opportunity now, for, in addition to such obvious readjustment and reconstruction work as the orderly reintroduction to industry of returned soldiers, the development of export trade, and the use of our productive capacity for our industries expanded by war needs, we can use, now, the opportunity to secure the adoption by the people generally of economic theories such as the husbanding of our exhaustible natural resources, such as coal and other fuels, iron, timber, etc., and we can also bring about now the adoption of policies which will insure the perpetual renewal of even the so-called inexhaustible natural resources, such as the soil and its products.

Proposal for an Advisory Council

An Advisory Council for the suggested commission should be selected from those who are especially charged with the conduct of affairs vital to the industrial, commercial, transportation, labor, financial and educational worlds. Realizing the demands made by the war on chief cabinet officers, it should not be expected that they should serve actively on such a Council, although in one or two cases, such as that of William P. G. Harding, the Governor of the Federal Reserve Board, principal officials, rather than those second in command, ought to be selected. In the case of legislators, many chairmmen of Senate and House committees are also too much occupied with war legislation to deal now with after-the-war problems. Officials of executive departments on such an Advisory Council should be charged not only with the duty of giving advice and outlining governmental policies of the present and possible policies of the future, but should detail to the service of the commission experts in their own departments. In the following list, strict order of precedence and rank in the Government is not followed, but such an Advisory Commission or Council should include:

Frank Lyon Polk, Counselor for the Department of State, for all international contact;

F. M. Simmons, Chairman of the Senate Committee on Finance, for contact on future Government revenues and taxes;

Claude M. Kitchin, Chairman of the House Ways and Means Committee, for contact on future Government revenues and taxes;

Duncan U. Fletcher, Chairman of the Senate Committee on Commerce, for contact on legislation affecting commerce;

Thetus W. Sims, Chairman of the House Committee on Interstate and Foreign Commerce, for contact on legislation affecting commerce;

Gilbert M. Hitchcock, Chairman of the Senate Committee on Foreign Relations, for contact on future international legislation;

Henry D. Flood, Chairman of the House Committee on Foreign Affairs, for contact on future international legislation;

John Bassett Moore, Vice Chairman, United States Section, International High Commission, for contact with international law, patents, trade-marks, etc., in Latin America;

John Barrett, Director General, Pan-American Union, for Latin American contact in detail;

William P. G. Harding, the Governor of the Federal Reserve Board, and Charles S. Hamlin, President of the Capital Issues Committee, and Sherman Allen, Treasurer of the War Finance Corporation, for contact on finance;

E. R. Stettinius, Assistant Secretary of War, for contact in industrial war production; and Rear Admiral Samuel McGowan, Paymaster General of the Navy, for contact on industrial naval production;

Maj. Gen. E. H. Crowder, Provost Marshal General, for contact on reintroducing returned soldiers to industry;

William H. Taft and Frank Walsh, Chairmen, War Labor Board, for contact with war labor problems and activities;

John A. McIlhenny, President, Civil Service Commission, for contact on Government employment;

Carl Vrooman, Assistant Secretary of Agriculture, for contact with the soil and its agricultural products;

Edwin F. Sweet, Assistant Secretary of Commerce, for contact with the Census and other Bureaus dealing with commerce;

William B. Colver, Chairman of the Federal Trade Commission, for contact with the coming administration of the Webb Act which permits combinations for foreign trade and for contact on unfair practices under the Newlands Act;

F. W. Taussig, Chairman, United States Tariff Commission, for contact on material now being gathered by Commission on after-the-war problems;

Raymond B. Stevens, Vice Chairman, United States Shipping Board, for contact on tonnage available after the war;

Herbert Hoover, United States Food Administrator, for contact on food licenses during reconstruction period and possible repeal of laws;

H. A. Garfield, United States Fuel Administrator, for distribution of coal and oil and possible repeal of laws during and after reconstruction period;

Walker D. Hines, Assistant to the Director General of Railroads, for contact with transportation and terminals after the war;

A. Mitchell Palmer, Alien Property Custodian of the United States, for final disposition of enemy-owned plants and other property;

Bernard M. Baruch, Chairman of the War Industries Board, for contact on sources of supply of raw materials and finished products;

Walter S. Gifford, Director of the Council of National Defense, for contact on reviving less essential industries;

Vance C. McCormick, Chairman, War Trade Board, for contact on licenses for imports and exports after the war;

Executive Secretary (when named) of the Water Power Commission of Cabinet Officers which is about to be created;

Daniel C. Roper, Commissioner of Internal Revenue, for contact on collection of excess profits taxes, etc.;

Charles D. Walcott, President, National Academy of Sciences, for Government contact with the sciences;

Charles F. Nesbit, Division of Military and Naval Insurance, for contact on personal insurance problems and defectives on his rolls who are returned soldiers;

Philander P. Claxton, Commissioner of Education and Secretary of the Federal Board for Vocational Education, for contact on educational statistics and statistics on defectives;

George Creel, Chairman, Committee on Public Information, for assistance and contact in educational work.

It is respectfully submitted that this is no mere list of names. Broadly speaking, it is an analysis of the industrial war organization of the United States, and a reading of the suggested contacts will show that the work of these officials, and that of their departments, bureaus and associates, will be just as vital to the solving of the after-the-war problems as it is vital to winning the war now. The two problems cannot be separated. All national contacts today are international. We think and move in terms of world-wide importance.

Industrial Changes Created by War

After four years of war, England has found it necessary to tear up and move to France between fifteen and twenty per cent. of her main line tracks. If the war lasts a long time, if there is not iron enough, if there is not steel enough, if there is not labor enough, if there is not constant maintenance, something like that might happen in this country. Then there will be need for actual physical reconstruction in this country, as there is abroad, instead of need merely for readjustment. Plans for such possibilities must be made now. Again, it is estimated that we shall have within a year forty-five to fifty million tons of steel-ingot-producing capacity and probably one hundred per cent greater finishing-machine-producing capacity than we had in 1913, in which year we were obliged in many lines to go abroad for a market for our surplus production. What plans are in the making for our surplus production after the war? Again, it is estimated that we shall have, with what we now have, 15,000,000 tons in merchant ships available after the war. What definite trade routes from American ports to the other ports of the world are being thought out?

No Central Government Agency Ready with Information Desired by Industry

The biggest American business which has been built up abroad has been in machine-finished steel products, such as talking machines and music machines, cash registers, agricultural machinery, adding machines, sewing machines, etc. Plans must be made to introduce these special products. One company now represented in Washington desires to open an office at Rio de Janeiro; another desires to send 600,000 tons of shipping to Australia next year. Is there any governmental agency or semi-governmental agency in Washington to offer encouragement or authoritative advice? No. What is being done to divert to American ports the rehandling business previously done in Europe, such as the bringing of rice from India, to reclean it, regrade it, and reship it; what is being done to hold for the United States the rubber now coming here to avoid two trips through the submarine zone which formerly went to England; what is being done to hold for the United States the business in tin which formerly went to England and Holland from Bolivia; what is being done to hold for the United States the business in coffee which originally went almost entirely to Europe, at which time we paid for the longer freight haul and commissions in London, Hamburg and Bremen, and much of which now comes to this country?

An Advisory Council such as has been outlined in this article, working with the proposed President's Readjustment and Reconstruction Committee or Commission, could answer these questions, if answers are in existence; and if not, could place industry through the Commission in a position to meet such problems as have been suggested, and a thousand more. The United States Tariff Commission is one of the few governmental agencies which is avowedly gathering data for after-the-war problems. The Federal Trade Commission, the Department of Commerce, and the War Trade Board are also collating some information. But there is no apparent co-ordination of these efforts, such as there is in England and other countries. The next article in this series will deal with what is being done in that respect in England.

Chemical Engineers Meet This Month

The summer meeting of the American Institute of Chemical Engineers will be held at Gorham and Berlin, N. H., Wednesday, June 19th to Saturday, June 22nd.

The following papers will be read and discussed:

The Human Element in the Mill, by Hugh K. Moore

Maintenance, Construction and Organization of Sulphite Mill, by Walter H. Taft.

The Seeding Method of Graining Sugar, by H. E Zitkowski.

The Manufacturer and Fuel Situation, by Wm. H Booth.

War Pyrotechnics, by G. A. Richter.

Food Conservation by Edw. Gudeman.

Chemical Stoneware and its Properties by A. Malinovszky.

Symposium on the Coal Tar Industry: Expansion of the Coal Tar Industry in the United States by F. E Dodge.

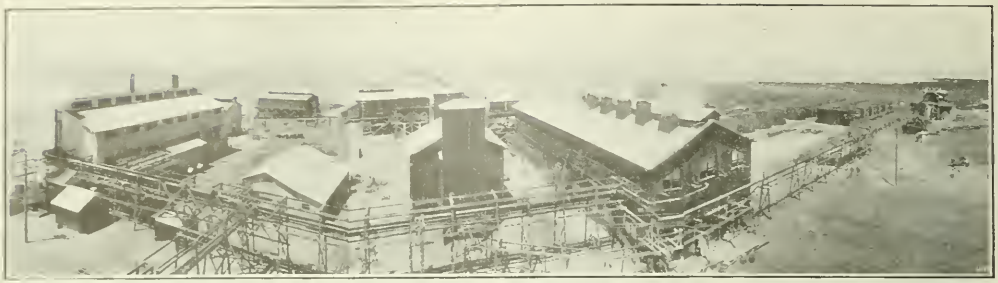
Expansion of the By-product Industry of Coal and Water Gas Plants in the United States by W. M. Russell.

Manufacture of Phenol by A. G. Peterkin.

Multiple Tangent System for the Manufacture of Sulphuric Acid by L. A. Thiele.

The following plants of the Brown Company will be visited under the leadership of Mr. Hugh K. Moore: The sulphite mill, the largest in the world; the saw mill and photographic department; the Cascade paper mill; the chemical plants, including electrolytic and caustic plants; fibre tube mill, carbon tetrachloride plant, chloroform plant and hydrogenated oil plant.

A joint meeting with the local section of the American Chemical Society will be held on Wednesday evening at the Mt. Madison House, Gorham, N. H. A unique feature of the program will be an entertainment by the employees of the Brown Company. Headquarters will be at the Mt. Madison House, Gorham, N. H.



The California Kelp Operations of the Hercules Powder Company

An American Industry Developed as a Result of a Demand for Acetone for Use in Munitions. An Example of American Chemical Engineering and Research Applied to a Pioneer Project

THE giant kelp of the Pacific Coast has provided a good deal of material for dreams and almost a hurricane of gossip, but detailed information of the industrial production of potash or anything else from this source has been scarce. Long lists of the botanical names of the various species of kelp have been published, and alluring notes on the K_2O content of dried material, showing amazing variations, have been recorded; but when engineering details were given, it has often happened that the information was inspired by some promotion scheme. On the other hand, time and again the possibilities of this kelp in industry have been made evident and our curiosity has grown alert to discover the actual progress of industrial research in the matter.

A little over a year ago Mr. H. L. Glaze of Los Angeles predicted in an article in this journal[1] that the crowning achievement along kelp-potash lines would be that of the Hercules Powder Co. on the bay at Potash, near San Diego. Other concerns have built plants and some seem to be succeeding, but the Hercules works at Potash are the largest of all and we are now in a position, thanks to a number of gentlemen connected with the company as its officers, to give a record of its achievements in research and industry.

It is interesting to note that the growth of this great undertaking and the working out of the processes have followed along different lines from those of others working in the same field. It was designed and built because the Powder Company had a contract to furnish the British Government a large quantity of powder, but the British Government did not want the Powder Company to compete against it for the large quantity of acetone required for the purpose. To complete the contract a new source of acetone had to be found and the Hercules people immediately began an exhaustive study of kelp with this in view. The results were very promising and in February, 1916, ground was broken for the works. By Fall of the same year the plant was completed and running. Thus the need of acetone was the main reason for establishing the plant, while the potash and many of the chemicals which have been produced may be classed as subsidiary products, although large in tonnage.

[1]Potash from Kelp in Southern California, April 1, 1916, p. 355 et seq.

Extensive Research Required

A great amount of research has been done by the company in the development of this undertaking; indeed a large number of both research and control chemists have been required from the start. In providing harvesters it has demanded the highest order of engineering skill and ingenuity to design or to adapt equipment to uses previously unknown to meet the unusual problems. New questions in practice arose daily and these had to be solved immediately or the operation of the plant would be interrupted.

As the fruit of intense research and untiring engineering application, the plant is now producing in substantial quantities, muriate of potash 95 to 98 per cent pure and practically free from sulphate, acetone that tests

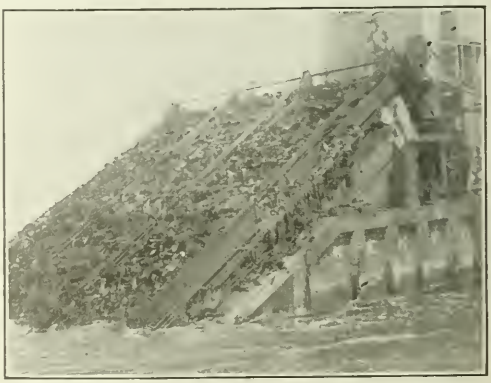


FIG. 2. HARVESTING KELP

better than the stringent specifications of the British Government, iodine U. S. P. and ethyl acetate meeting all the usual commercial specifications. In addition to all these well known chemicals, the works are producing ethyl propionate and ethyl butyrate on a scale never before approached. These latter solvents are especially interesting as amyl acetate substitutes on account of the efforts which the U. S. Government is now making to conserve acetate of lime.

General Features of the Project

The plant shown in the general view, Fig. 1, is located on the bay at Potash, near San Diego. Over $5,000,000 has been spent in its construction and operation, and it covers about 30 acres. It uses about 6000 boiler horsepower and approximately 1000 men are employed, including from 75 to 100 at sea on harvesting work. Chemical control involves from 1500 to 2000 tests daily. The research staff numbers from 15 to 20 and this work is housed entirely separate from the control laboratories. The company is cutting about three-fourths of all the kelp cut on the Pacific Coast. In 1917 it averaged about 24,000 tons per month.

Harvesting the Kelp

This is the first step in the process. The designing of harvesters began as soon as the plant was started. Although about 100 patents had been taken out by other inventors, no really efficient design of harvester for large-scale work existed at that time. The system which has proved satisfactory consists in a combination of harvesters, barges and tugs. Fig. 2 shows a harvester in operation, with the freshly cut kelp carried up from the water by moving screens. From the screens it passes through macerators and thence into the hold of the harvester vessel and from this point it is pumped through a pipe boom to a barge, as shown in Figs. 3 and 4. The cutters or harvesters are ocean-going boats and stay out at sea all the time, while the barges carry the macerated kelp back to the wharf where it is pumped from the holds into fermenting tanks which are shown in the general panorama in Fig. 1, and also in Figs. 6 and 7. Pumping kelp was a problem at first but it was solved by a model of a Goulds rotary pump. Foreign matter such as bolts, nuts, etc., brought in with the kelp are removed by electromagnets before the pumps are reached.

FIG. 4 BARGE BEING FILLED WITH KELP

Harvesting consists in cutting the plant about six feet below the surface of the water. It has actually been found that this treatment improves the growth and stand of the beds to such an extent that they may be cut over about every ninety days. The area cut at present extends from Pt. Conception south to the Mexican line.

Fermentation of Kelp Pulp

After it is pumped to the redwood tanks shown in Figs. 6 and 7 the kelp is diluted to a certain point and allowed to ferment under the correct temperature conditions. This unit is believed to be the largest in the world and comprises over 150 tanks of 25 ft. diameter, holding 50,000 gal. each. Each tank is equipped with hot-water coils for temperature regulation and compressed-air pipes are arranged to provide the proper agitation. Railroad tracks are laid between the batteries of tanks, and here Brownhoist locomotive trains are operated to load material upon the bridges which connect the tanks. Fermentation takes from ten days to two weeks and sometimes more. The organic acids, acetic, butyric, propionic, etc., are formed during the process and, by the addition of lime, their respective calcium salts are produced. These go into solution together with the potash and other soluble salts which are

FIG. 3. PUMPING KELP FROM HARVESTER TO BARGE

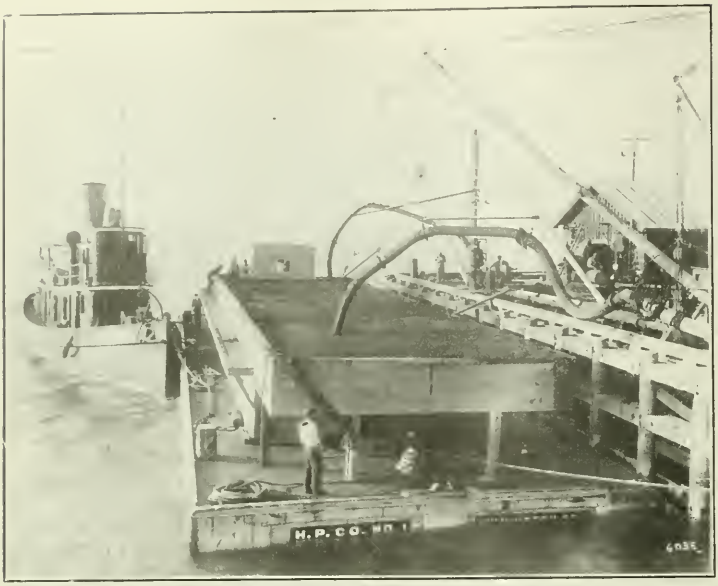


FIG. 5. DISCHARGING A BARGE-LOAD OF KELP

released as the fermenting process breaks down the cells of the kelp.

Separation Processes

After the fermenting period the resultant liquor is screened to remove undigested matter, following which the solution is allowed to settle. It is then filtered. The clear liquor contains potassium and sodium chlorides and the calcium salts of various fatty acids, but chiefly of acetic, butyric and propionic. The filter press building is shown in Fig. 8 with the Oliver press in the background and the two Kelly presses to the fore. The residue left from screening is still waste, and is discharged as refuse.

Evaporation is conducted in quadruple effect Kestner vacuum evaporators, shown in Fig. 9. They are operated with exhaust steam at a maximum pressure of 5 lb., and with a vacuum of about 26 inches. Triplex plunger pumps are used at this point. The principal trouble in evaporation has been to keep the evaporator tubes free from scale. After evaporation to a certain point the liquors are allowed to crystallize, and the first product to come to the top is a mixture of the calcium salts of the fatty acids, which from its nature has been named "taffy." This taffy is removed and subsequently made into high-grade solvents. The next body to crystallize is calcium acetate, which contains some potash, and at this point the liquor is removed and cooled. Then the bulk of the potash comes down as 95 to 98 per cent pure potassium chloride. A view of the lower floor of the crystallizing house is shown in Fig. 10. The salt chambers and cone bottoms of the cold kettles are shown on the left and the hot kettles to the right. Fig. 11 shows the upper floor of the same building with the same arrangement: cold kettles on the left and hot kettles on the right.

Later Treatment of Crystallized Products

As stated above, the taffy, which is obtained as the first product, contains salts of fatty acids of the acetic series. It has been found possible, after considerable research, to make from this such products as ethyl butyrate, ethyl propionate, etc., and methyl-ethyl-ketone as well as higher ketones, on a considerable scale. This is a noteworthy development inasmuch as it opens up a new source of supply of high-grade solvents which heretofore have been made entirely from calcium acetate. In fact, the solvent situation has been so serious that the U. S. Government has placed restrictions upon the use of calcium acetate. This development of an entirely new supply of solvents will surely be welcomed by important chemical industries which depend for their

FIG. 6. TANK FARM FOR FERMENTATION OF KELP

FIG. 7. INTERIOR VIEW OF TANK

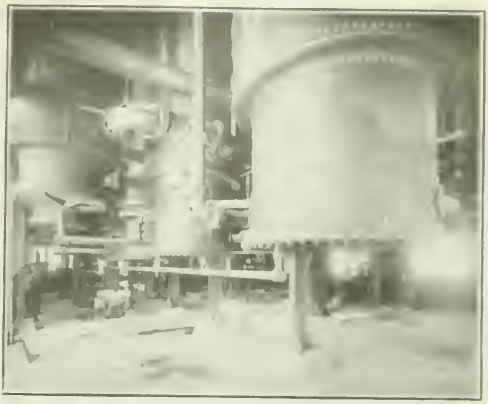


FIG. 6. LOWER FLOOR OF EVAPORATOR PLANT

existence on a constant supply of standard solvents such as ethyl acetate, amyl acetate, etc. Indeed, it seems probable that for the first time in the history of chemical industry, a practical supply of ethyl butyrate and propionate is placed within reach. These esters, being almost identical in physical characteristics, more particularly in regard to their boiling points, solvent power, freedom from residual odors, etc., form very desirable substitutes for amyl acetate and other solvents of a like nature.

The next product, calcium acetate containing some potash, is used to produce acetone, while the residue from distillation contains potash and the iodides. This is further separated with the production of high-grade iodine and more potash (chloride), which, like the product of the first crystallization, runs above 95 per cent in purity and is practically free from the sulphate. All potash is carried from the salt chambers to the centrifugal building by side-dump buckets, where they are elevated to Tolhurst centrifugals. After centrifuging the crystals are dried in steam-jacketed rotary dryers and then sacked and are ready for shipment.

The Finished Product

A feature of singular interest is the purity of these kelp products. It is fair to say that these results have become possible only after long and arduous research; that the separations of the organic esters are difficult and that the work involved great experimentation. The field was new and processes and apparatus had to be established and designed *de novo* to meet some conditions while standard apparatus had to be radically rearranged to meet others. Indeed, these difficulties presented themselves at every step in the organization of the plant. Ethyl acetate and ethyl anhydride are also made, the latter being used to produce cellulose acetate for non-inflammable aeroplane dope.

The potash is all used for chemical purposes, owing to its unique purity, and there is not enough of it to supply this demand. The total quantity of the pure product is not great enough to be considered seriously for fertilizer purposes. There are, however, a number of residues produced which contain potash which amount to quite a tonnage and these offer interesting and attractive possibilities in which fertilizers are to be considered. Research is in process in regard to these residues. To the chemical trade, however, the products of special interest are the 95-98 per cent KCl and the organic solvents.

Everything points to the permanency of this industry.

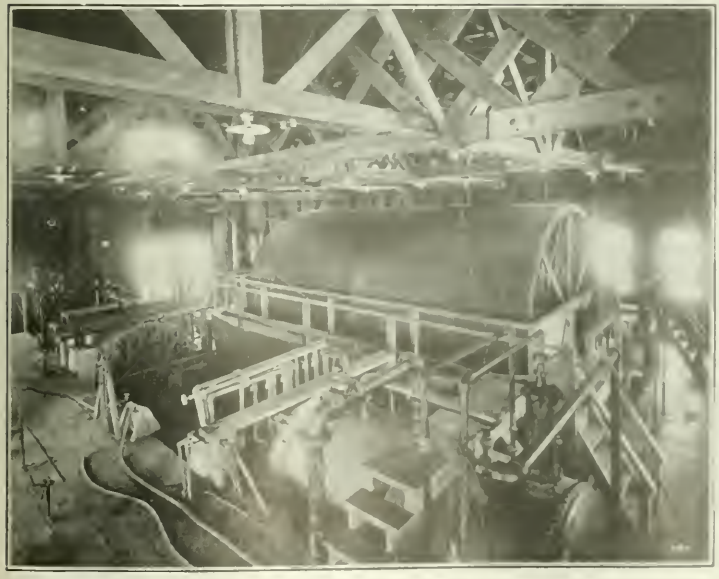


FIG. 8. INTERIOR OF FILTRATION PLANT

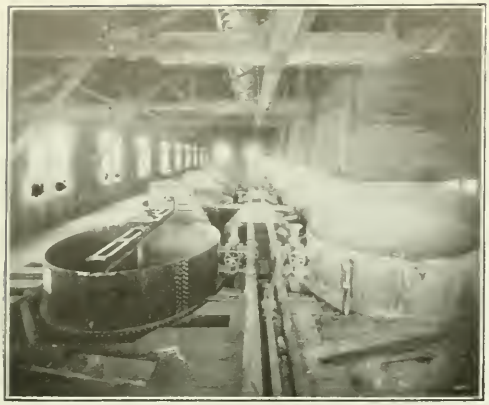


FIG. 11. UPPER FLOOR OF CRYSTALLIZING HOUSE

The statements published as to the amount of potash, iodine and other constituents of kelp and as to the quantity of the available kelp itself have, as a rule, been greatly exaggerated. It is doubtful if this will ever be a really important source of fertilizer potash for which, although the quality is not important, an immense tonnage is required. At this establishment, the promise of permanence lies in the quality of its products. After the war demand ceases, the chemical industry will surely want the KCl for the production of potash salts; and the solvents have long been needed.

The company plans to have a comprehensive exhibit showing the various stages of the work and samples of its products at the Fourth National Exposition of Chemical Industries which will be held in New York City next September.

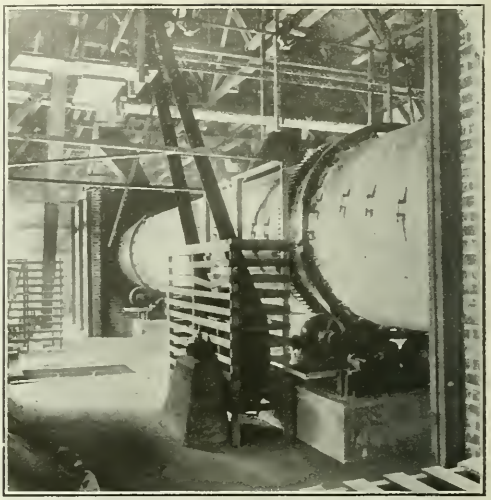


FIG. 12. ROTARY DRYER FOR POTASH

The British Nonferrous Metal Industry Act.—This act is characterized by *Commerce Reports* as marking another step in British preparations for trade after the war of almost equal importance with the Imports and Exports Bill. Its effect cannot be predicted owing to the broad discretionary powers vested in the Board of Trade. All houses carrying on the "business of winning, extracting, smelting, dressing, refining or dealing" in more than 25 tons of zinc, copper or lead quarterly, or more than 5 tons of tin, nickel or aluminium, metal, scrap, or ore must be licensed. The Board of Trade may refuse licenses to houses to which any one of six conditions apply, one of which, the most inclusive, is: "That the company, firm or individual is by any means whatever, subject, directly or indirectly, in the conduct of their or his business to enemy influence or association." Companies must recall all unregistered stock carrying voting power in the management. The applicant for license must furnish detailed information as to the names and nationalities of all officers, shareholders and members, the location and management of foreign branches, and declarations as to any connection with enemy firms dealing in nonferrous metals and ores.

The act is unusually broad and will have a large influence in determining post-war conditions in Great Britain.

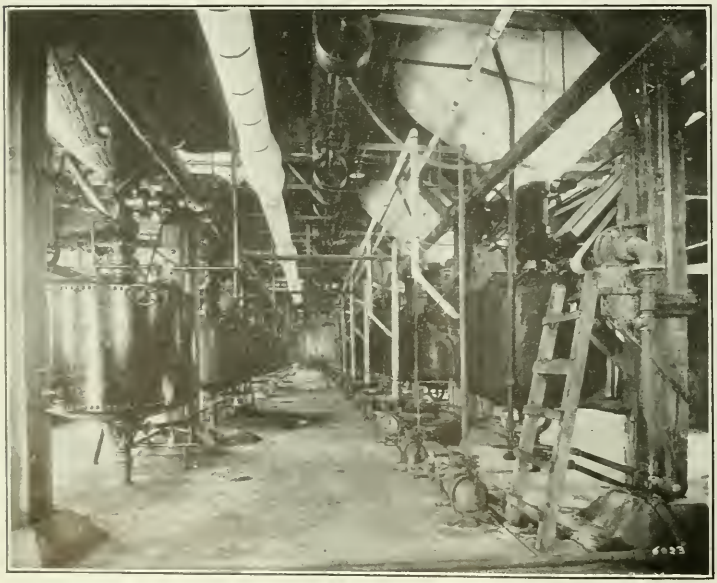


FIG. 10. LOWER FLOOR OF CRYSTALLIZING HOUSE

Electrochemistry and National Economy*

By Colin G. Fink

THE American Electrochemical Society considers itself very fortunate indeed to have been afforded the opportunity of undertaking this most interesting and highly instructive trip through the Appalachian South. What we have already seen more than convinces us that the Appalachian South is rapidly developing into one of the leading industrial centers of the world. We electrochemical engineers look upon Muscle Shoals as the new Niagara, the Niagara of the South! What constitutes an electrochemical industrial center? What are the essential requisites? What are the raw materials necessary for the production of that long list of metals, alloys, carbides, fertilizers, explosives, abrasives, lubricants, solvents, refractories, disinfectants, electrodes, and gases for cutting and welding? The first essential is an abundant supply of cheap power—power to be had in large blocks for 24 hours a day and 365 days a year! Cheap power is almost always synonymous with water power—and of this the Appalachian South has been supplied by nature in gracious abundance. In the state of Tennessee alone, according to the estimates of Prof. J. A. Switzer, there are available almost one million horsepower. In other words, Tennessee alone has enough power available to foster an electrochemical industry twice the size of that existing at Niagara Falls today!

Nitrogen-Fixation Plants in the South

When our Government decided to establish the nitrogen fixation industry in this country and considered the various localities suitable for the electrochemical production of those most vital compounds, ammonia and nitrates—without which we could neither feed our populace nor defend our borders—our Government, after due deliberation, most wisely decided to erect the "air saltpeter" factories at Muscle Shoals, Alabama. Therefore as regards the supply of cheap water power in the Appalachian South there is no doubt. Careful surveys have reported a vast abundance. In this connection it is gratifying indeed to note that the United States Chamber of Commerce, comprised of 500,000 business executives from every state and territory in the country, unanimously adopted resolutions calling on Congress to make provisions for harnessing the millions in water horsepower that are now going to waste.

The development of our water-power resources is of prime national economic value. It means the saving of coal and oil, which though most abundant here in the South are nevertheless exhaustible, and once used can never be replaced. It means the saving of railroad equipment now used for the transportation of coal and oil; it means the saving of a long list of valuable chemical products now burned and wasted under thousands of boilers; and it means the saving of millions of dollars in labor. The water power generated in the Province of Ontario, Canada, has reduced coal consumption between 5,000,000 and 6,000,000 tons per annum. Under fairly efficient working conditions it requires from 2 to 6 pounds of coal to generate power equivalent to one horsepower-hour. Think of the tons and tons of coal represented by the available water power of this country, which is estimated by the Geological Survey at 32,000,000 hp. minimum potential.

The By-Product Value of Coal

The electrochemist looks upon the vast coal resources of the Appalachian South as intended for purposes of greater economic value. The coal reserves of a single state, West Virginia, have been calculated at 150,000,000 tons. The southern coal makes the best coke, and very valuable by-products are thereby conserved. Alabama is second largest coke-producing state in the country. Tons of coke are shipped from the South to Niagara Falls and there heated in contact with sand in large electric furnaces that produce temperatures that are higher than can be attained in any other way. A beautiful crystalline product is obtained, carborundum, a silicon carbide, an abrasive which has found world-wide application. Another important electrochemical product largely dependent upon Appalachian coke is calcium carbide. This was first made by Willson at Spray, North Carolina, by mixing ordinary limestone and coke and heating to very high temperatures in the electric furnace. Calcium carbide is the source of acetylene, which is used in conjunction with electrolytically produced oxygen in the oxy-acetylene torch for steel welding and steel cutting. You are all familiar with this time and labor-saving device! Calcium carbide furthermore serves as the "raw material" in the electrochemical manufacture of cyanamide, which the Government will soon be turning out by the ton at Muscle Shoals. It is a very efficient fertilizer. Another and very recent by-product of calcium carbide is acetone, consumed in large quantities in the manufacture of explosives. There seems to be no end to the list of compounds and products of inestimable worth that are all primarily derived from Appalachian coke.

Aluminum and Abrasives from Bauxite

The South has been most strikingly favored by nature in the line of raw materials for electrochemical products. Next in importance to her coke resources are her extended deposits of bauxite, the basic mineral from which that metal of many uses, aluminium, is derived. The aluminium industry of this country ranks among the very first and consumes almost as much in kilowatts as all the other electrochemical industries put together. There are but four states in the whole country that have been mining bauxite in commercial quantities—Arkansas, Georgia, Alabama and Tennessee. In 1917 these states turned out 400,000 metric tons of bauxite, which is 12 per cent more than the world's bauxite output of the year 1910. The Aluminum Company of America has a large metal-producing plant at Maryville, Tennessee. This appears to us as a very wise move. Why ship bauxite by freight hundreds of miles away? Why not make the metal near the source of the raw material? It requires 2 tons of bauxite for one ton of aluminium metal.

Bauxite is also used for the manufacture of aloxite and alundum, artificial emeries of great hardness and uniformity which are made in electric furnaces at Niagara Falls. The artificial abrasives, alundum, aloxite and carborundum have practically replaced imported emery and corundum. These electric furnace abra-

*Presidential Address, 33rd General Meeting American Electrochemical Society, Knoxville, Tenn., April 30, 1918.

sives have virtually revolutionized the machine shops, doubling and trebling their output.

An electrochemical industry which is most typically American is the electrolytic copper refining industry. Over 75 per cent of the copper consumed today is purified and refined by electrochemical methods; it is of the highest attainable quality, exceeding in purity Sterling silver. The largest electrolytic copper plant in the world is located at Canton, Maryland, with an annual production of 720,000,000 pounds. The modern electrical industry with its dynamos and motors, its telephone, telegraph and wireless and its countless electromagnetic devices would be helplessly crippled if we were to deprive it of electrolytic copper.

In the electric steel industry the United States likewise leads the world. The quality of electric steel surpasses that of the best crucible steel. Next to Minnesota and Michigan, Alabama is the largest iron-producing state in the Union. Over 50 per cent of the iron ore reserves of the U. S. are located here in the South.

Closely linked with the electric steel industry is the ferro-alloy industry—Ferromanganese, ferrosilicon, ferrochromium, ferrotitanium and others. Ferrosilicon and other ferro-alloys are electrically made by the Southern Ferro Alloys Co. at Chattanooga, Tennessee. Electric ferromanganese is made by the Southern Manganese Corporation at Anniston, Alabama.

Deposits of manganese occur in many parts of the United States but are most abundant in the Appalachian and Piedmont region, Virginia and Georgia being the largest producers. Silicon is derived from quartz rock and sand. Titanium is derived from the mineral "rutile." For many years the sole producer of rutile in this country has been the American Rutile Company whose plant is at Roseland, Virginia. Rails made of steel to which ferrotitanium was added during the process of manufacture, are less liable to breakage and are 40 per cent more durable than are ordinary open-hearth rails. Another electric titanium alloy is cuprotitanium, containing 10 per cent titanium and 90 per cent copper. This is extensively used in making sound castings of copper and bronze.

Carbon bisulphide is a solvent upon which the rubber industry is very much dependent. Formerly it was made by long tedious and expensive processes. Today all carbon bisulphide is made electrochemically. The raw materials are charcoal and sulphur. The great sulphur states of the world are Louisiana and Texas. The combined output of these two states exceeds not only that of all other states put together but that of all the rest of the world. One of many wells of the Union Sulphur Company discharges 500 tons of sulphur per day.

Modern Versus Earlier Processes

If we arrange the electrochemical industries according to the number of factories and the total power consumed, both in this country and abroad, we find that the electrolytic alkali and chlorine industry ranks fourth in the list. What a long array of interesting and important products have been developed and turned out by the ton by this industry: caustic soda and bleach, chlorine gas, sodium metal, disinfectants and peroxides and a series of valuable compounds! The basic raw material is common salt, NaCl, and it is interesting to note that Virginia is sixth largest salt-producing state in the country. The electrochemist takes this salt, dissolves it in water and passes a current of electricity through the solution. How simple is this electrolytic method compared to the old fashioned process of producing alkali and chlorine, according to which you had to start out with pyrites or sulphur, oxidize this to sulphuric caid, add this acid to salt thereby liberating hydrochloric acid; then taking this acid and treating it with manganese peroxide to "free" the chlorine gas; the sodium sulphate, obtained by adding the sulphuric acid to sodium chloride, was dried, mixed with coke and limestone and transformed by heat into calcium sulphide and sodium carbonate; finally the sodium carbonate was dissolved in water and boiled with lime producing sodium hydrate or alkali. We certainly need not emphasize that electrolytic alkali spells economy. Think of all the labor and power that is conserved!

One of the most recent achievements of the electrochemist is the commercial production of electrolytic tin. Unfortunately, outside of Alaska, our country has no large tin deposits. The electrolytic tin refining plant at Perth Amboy derives practically all of its ore from Bolivia. However, during recent years our government has undertaken an earnest search for tin in this country and it is gratifying to read the recent report of the U. S. Geological Survey on promising deposits developed in the Kings Mountain and Lincolnton districts, North Carolina and in Rockbridge County, Virginia. So that it seems if we are to have any tin industry at all it will be here in the south.

Truly, nature has been most lavish with her treasures here in the South and the electrochemical engineer finds in this region, rich in natural resources, water power, iron, coal, phosphates, manganese, aluminium, titanium, quartz, salt, copper, pyrites and limestone, the most ideal localities for the founding and fostering of important electrochemical centers.

Instructors Wanted for Engineers Training School

The Government proposes to establish immediately at Camp Humphreys, Va., a training school for replacement troops of the Engineer Corps. These men will be given intensive training to fit them for the special service required in connection with the various engineer units in the service. A complete school in which all the trades as identified with the engineer units of the Army will be taught by means of short intense courses.

As this school will have an ultimate capacity of approximately 30,000 men, many instructors will be required and an appeal is made to the qualified men beyond the draft age who are willing to volunteer their services and enlist in the Engineer Corps as instructors in this school. The requirements are: a thorough knowledge of the following branches—machinists, blacksmiths, wheelwrights, carpenters, concrete foremen, electricians, dynamo experts, miners, painters, riggers, sheet metal workers, foundrymen, automobile and motor trucks, gas engine men, draftsmen, photographers and general foremen of construction.

Full particulars and application blanks will be furnished by applying to Captain Louis T. Grant, E.R.C., Secretary, Engineer Training Schools, Camp Humphreys, Va.

A Rocking Electric Brass Furnace

A New Type of Arc Furnace Developed by Metallurgists of the U. S. Bureau of Mines—Comparison with Other Types—Record of Comparative Tests with Coke-fired Furnaces—Power Consumption and Costs

By H. W. GILLETT and A. E. RHOADS

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IT SEEMS inevitable that the next few years will see electric furnaces largely replacing crucible furnaces in the brass industry; a development comparable to that which the last few years have seen in the steel industry.

With Klingenberg clay not available, and Ceylon graphite requiring ships needed for other purposes, crucibles, despite the good work done by crucible manufacturers, the Bureau of Standards, and others on the problem, are, speaking generally, still of much poorer quality, and many times more costly, than they were under pre-war conditions. The time is ripe for the practical elimination of the crucible from the brass industry.

With the huge tonnage of brass required for war purposes, the use of the small units—averaging 200 lb. per charge—in which crucible melting is done by the brass rolling mills, seems, and is, an anachronism. Besides the avoidance of crucibles and the ability to melt larger charges, electric melting (in a suitable type of furnace) decreases the loss of metal by oxidation and volatilization, prevents the taking up of sulphur from the fuel, gives better and more healthful working conditions, and has many minor advantages such as freedom from handling and storing fuel and ash. Electric furnaces give crucible quality of metal without using crucibles.

Brass Melting Requires Furnaces of Special Characteristics

However not every type of electric furnace can be used for brass melting. If brass did not differ materially from steel in its behavior during melting, electric furnaces would long ago have superseded crucible furnaces. But brass is made up of copper and zinc, and zinc is volatile at brass melting temperatures. For this reason, fuel-fired furnaces of the reverberatory type can be applied to brass only at the expense of a zinc loss so high as to prohibit the procedure. Similarly, the direct-arc type of electric furnace used for steel melting, such as the Heroult, can be used only on bronzes practically free from zinc, because of the high local temperature of the metal under the arc.

Indirect-arc furnaces, such as the Rennerfelt, can be used on brasses containing up to about 20 per cent zinc, but are not suitable for ordinary yellow brass, on account of the formation of a superheated layer on the surface of the bath beneath the arc, and the resulting volatilization of zinc.

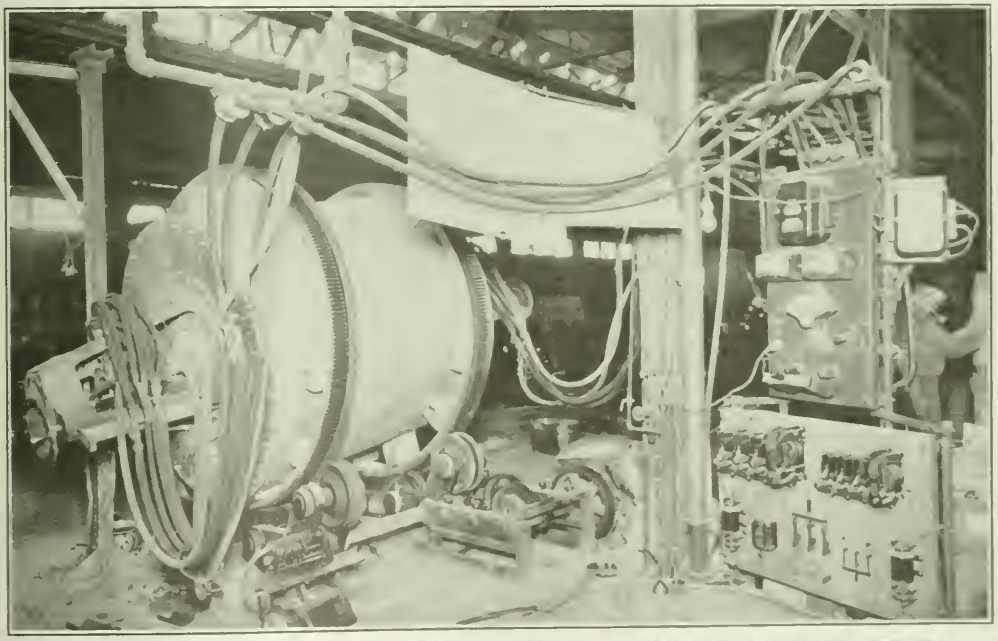


FIG. 1. REVOLVING ELECTRIC BRASS FURNACE AT MICHIGAN SMELTING & REFINING CO., DETROIT

Induction furnaces of the ordinary horizontal-ring type, like the Rochling-Rodenhauser, cannot be used on brass or bronze because the high electrical conductivity of these alloys requires a secondary current so high that the "pinch effect" causes rupture of the secondary ring.

Hence it has been necessary to develop types of furnaces radically different from those in use for steel in order to meet the requirements of brass.

Electric Brass Furnaces in Commercial Use

There are, however, two types of steel furnaces which have been applied to brass (using the term brass loosely to include bronze, red brass, etc.), the Snyder, a single-phase direct-arc furnace, and the Rennerfelt, a two-phase indirect-arc furnace. At the Chicago Bearing Metal Company, Chicago, Ill., two one-ton Snyder and two one-ton Rennerfelt furnaces are melting bronze for railroad bearings, high in lead, but practically free from zinc. The metal losses are not much reduced from previous practice in crucibles and open-flame oil furnaces, but the furnaces are making savings in melting cost as compared with either the crucible or the open-flame furnaces under present conditions.

The Philadelphia Mint is melting nickel and coinage bronze in a 1000-lb. Rennerfelt furnace. The Gerline Brass Foundry Company, Kalamazoo, Michigan, melts Monel metal, red brass and brass containing up to about 20 per cent zinc in an 800-lb. Rennerfelt. The furnace at the Gerline plant is run on a 9-hour basis, while the other furnaces mentioned operate 18 to 24 hours a day.

Two other types of furnace designed especially for brass melting, have also found commercial use, the Baily and the Ajax-Wyatt.

The Baily furnace uses a single-phase granular resistor, the heat from which is reflected down onto the hearth from the roof. It takes charges of about 1000 lb. Baily furnaces are installed at the Lumen Bearing Company, Buffalo, N. Y., Hays Mfg. Co., Erie, Pa., Bridgeport Brass Co., Bridgeport, Conn., and the Baltimore Copper Smelting and Rolling Company, Baltimore. Md. The Baily furnace is applicable to alloys of any zinc content, reduces metal losses, avoids crucibles, and gives good working conditions. The main drawback of this type of furnace is that the source of heat is not close to the melt and the heat must be reflected down from the roof. In order not to overheat the roof and cause its prompt failure, as well as to hold the resistor temperature within the limits that allow reasonable life of the resistor trough, the rate of power input is low compared to the size of the furnace and weight of charge. Hence the radiation losses from walls and roof form a large proportion of the total power. The furnace is at its best on 24-hour operation. When 10-hour operation is necessary, it is found that the furnace must be heated empty during all or part of the night in order to give satisfactory output in the daytime. Because of the high heat storage in the walls, a furnace of this type does not respond promptly to changes in power input, and accurate control of the temperature of the melt is difficult.

The Ajax-Wyatt furnace is a single-phase induction furnace in which the secondary ring is in the form of a loop below the level of the hearth proper, so that the hydraulic head of the metal in the hearth opposes the rupturing effect of the "pinch" force, thus avoiding the troubles that make horizontal-ring induction furnaces inapplicable to brass.

The metal heated in the secondary loop is constantly ejected at one part of each opening from loop to hearth, and colder molten metal drawn in at another part of the opening. These fountains of hot metal issuing from the resistor melt the charge in the hearth. The constant circulation of metal is a most desirable feature and gives a product of remarkably uniform chemical composition.

Because of the compactness of the furnace, the generation of heat within the metal itself, and the stirring action, vertical-ring-induction furnaces are extremely

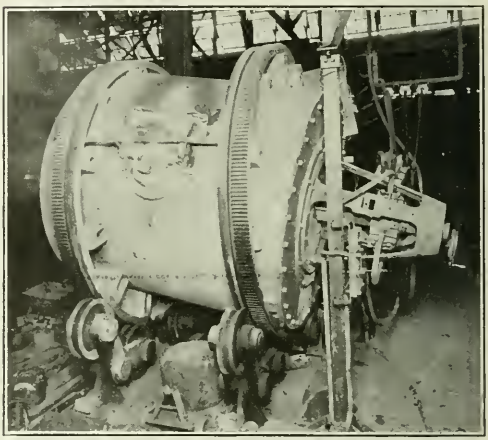


FIG. 2. ANOTHER VIEW OF THE REVOLVING ELECTRIC BRASS FURNACE

efficient as regards power consumption. The power factor, in the sizes so far built, is satisfactory.

The furnace must be started with a charge of previously melted metal, and sufficient metal to fill the loop must be retained when pouring. The metal in the loop must never be allowed to solidify, or the lining will be ruined. These facts make it difficult to change from one alloy to another, and require that the furnace be run 24 hours a day, or else receive enough power at night to keep the metal in the loop fluid. Ramming up and drying the refractory lining of the loop is a job requiring care and experience, as the lining must be perfect or its life will be short. No lining has yet been found that will withstand alloys containing over 3 per cent of lead, and the furnace has been developed mainly for yellow brass.

The furnace is fitted for rolling mill use, where 24-hour operation on yellow brass is the rule, but is distinctly less suitable for 10-hour runs or for foundries making a variety of alloys.

Several of these furnaces are in use at the Ajax Metal Company, Philadelphia, two at the American Brass Company, Waterbury, Conn., and twenty-eight at the Bridgeport Brass Co., Bridgeport, Conn. The furnace saves zinc, avoids crucibles, and shows so low a power consumption on 24-hour operation that it can doubtless be used to advantage in rolling mill practice even under normal prices of fuel and crucibles.

Furnaces Under Experimental Test

Besides the four types mentioned above, each of which has found commercial use where conditions were suitable, there are four other furnaces that have reached a semi-commercial stage, but are still under experimental development.

The Bennett furnace at the Scovill Mfg. Co., Waterbury, Conn., is a three-phase furnace, probably of about 750-lb. capacity, and resembles a direct-arc furnace. However, the voltage between electrodes (which are automatically regulated) and bath is kept so low that there is no true arc and the heat is generated by a sort of contact resistance. This is said to give low metal losses and to show a reasonably low consumption of power.

The furnace has run mainly on yellow brass and is therefore probably applicable to all brasses and bronzes. The results of the work have so far been kept secret and no detailed data are available.

The Foley furnace is a single-phase, vertical-ring induction furnace, similar in general design to the Ajax-Wyatt, although differing from it in many points. One such furnace of about 1000-lb. capacity has been in experimental operation at the Bristol Brass Company, Bristol, Conn., and three 3000-lb. furnaces are under construction. From the few data so far available on this furnace, its metal losses and power consumption will be about the same as in the Ajax-Wyatt; partly because of larger size its power factor is somewhat lower. It has the same disadvantages as regards starting, changing from one alloy to another, and the necessity for 24-hour operation, as that furnace.

The General Electric furnace is a smothered-arc, one or two-phase furnace, normally two of about 1500-lb. capacity, having four depending electrodes, two on each side of a hearth. Between the tips of each pair of electrodes is a carbon block to which arcs are drawn, the arcs being smothered by granular coke. The heat thus generated is reflected down onto the hearth by the roof. The electrodes are automatically regulated.

After being tested at the General Electric Company, Schenectady, N. Y., this furnace has been installed for further test at the Chicago plant of the Crane Company, but is not yet considered ready for general commercial use.

The heat transfer in this type is similar to that in the Baily, and the furnace seems theoretically capable of a performance of about the same order as the Baily with similar advantages and similar drawbacks. As the General Electric furnace takes a higher power input than the Baily, it may be slightly more efficient in power consumption, but the roof is subject to even more severe conditions and will require the use of high grade refractories to give a good life.

The Northrup furnace, being developed by Prof. E. F. Northrup and the Ajax Metal Company, is an induction furnace, heating the charge by means of eddy currents instead of making the charge, or part of it, the secondary of a transformer. Oscillating current of very high frequency is used instead of alternating current, and is obtained by the use of condensers or a special generator. A 60-kw. tapping-type furnace is being tried out. The Northrup furnace has a high power factor, and can take multiphase current. It is being developed in order to produce a furnace suitable for 10-hour operation and for facility in changing from one alloy to another.

Since the heat is generated within the charge itself, the eddy current furnace should be efficient in power consumption. This type is theoretically very promising, but its development has not yet gone far enough to show what, if any, mechanical limitations the type will have.

Many other types of furnaces have been suggested for brass melting, and a number have been tried out more or less thoroughly, but those mentioned above are the most prominent of the types in commercial use or under commercial development. Most of these are either limited in their application, or have some drawbacks, either inherent in the type of furnace, or not yet eliminated by long experience in their design and use, so that no one type or make of furnace is as yet definitely proved the best for any particular set of conditions, and still less will any one furnace meet all the different conditions found in the whole range of the brass and bronze industry.

In particular, none of these types seems quite fitted to that common set of conditions where a furnace may be called upon to melt successive heats of alloys differing widely in composition, to handle both alloys free from zinc and those high in zinc, and to operate cheaply on a 9 or 10-hour day.

Rocking Electric Brass Furnace

In its study of electric brass melting during the past five years, the Bureau of Mines has tried out a rocking-type of furnace, which may perhaps help to fill this gap.

In the ordinary indirect-arc type of furnace, the heat is applied above the melt and as hot metal is lighter than colder metal, there is little circulation in the bath. If the rate of heat input is at all rapid, as is necessary for thermal efficiency, heat conduction from the top of the melt downward does not keep pace with the heat supply. Before the melt as a whole reaches the proper pouring temperature, the surface is much superheated.

On an alloy high in zinc the surface will reach the boiling point of the zinc in that particular alloy while the bottom is scarcely melted. Such heating creates a high pressure of zinc vapor within the furnace so that if it is not tightly closed, zinc is lost continually. If the furnace is sealed tight, the pressure may even blow out the roof or door. In case the furnace holds tight and the pressure is not relieved till the spout is opened for pouring a long hissing stream of zinc vapor then shoots out, burning in the air. This local overheating is the cause of the failure of the indirect-arc furnace to handle alloys high in zinc without large metal losses.

The obvious way to overcome this trouble is to stir the melt so vigorously that the temperature of the melt is practically uniform and the superheating of the surface prevented. The most practical way to stir the melt is by the principle of the cement-mixer, by turning the furnace bodily so as to stir the contents thoroughly while being heated. Constant rotation of a cylindrical furnace placed more or less horizontally, but preferably at a slight angle with the horizontal to produce endwise motion of the melt during rotation, with electrodes entering at the ends of the drum and an arc struck between the electrodes should not only stir the charge thoroughly, avoid surface over-heating and thus pre-

vent zinc losses, but should also give a well-mixed alloy. By washing the walls with metal the heat stored in the walls and roof should be largely taken up in the metal instead of passing out. The power consumption should therefore be low. As the walls are washed with metal their temperature can rise but little above the temperature of the metal, which should give a good life of lining.

Instead of rotating the furnace through a complete revolution which would involve difficulty in keeping the metal out of the joints between the door and the door opening, as this opening should be on the circumference of the drum rather than on the end—and in making brush contacts to the electrodes, it appears simpler to rock the furnace back and forth so that the molten charge just fails to reach the door at either end of its rocking angle.

Results of Laboratory Tests

A small furnace of this type was built and tried out. This was rocked back and forth by hand on tracks. It was cheaply constructed from materials at hand in the laboratory and was not expected to give very good results on power consumption, as the drum was too small to allow the refractory lining to be of desirable thickness.

The laboratory furnace held about 100 lb. of charge, and operated on 50 to 75 volts and 500 to 700 amperes at a power factor of 85 to 90. The usual power input was about 30 kw. Graphite electrodes 2 in. in diameter were used.

A number of different alloys were melted in the rocking furnace. In melting 1092.1 lb. of yellow brass, made up of 45 per cent ingot, 55 per cent copper and zinc, the calculated analysis being 65.6 per cent Cu, 34.4 per cent Zn, 1080.4 lb. of ingot was obtained, analyzing 65.9 per cent copper, 34.1 per cent zinc. The metal loss by weight was 1.06 per cent which includes both volatilization and mechanical loss by spatter in pouring. The average pouring temperature was 1080 deg. C.

On manganese-bronze chips (40 per cent zinc) the furnace gave a net metal loss of 3.0 per cent while the same lot of chips melted in oil-fired crucible furnaces in commercial practice gave 7.2 per cent loss.

Yellow brass chips (25 per cent zinc) gave 1.6 per cent net loss, red brass chips (10 per cent zinc) 1.0 per cent.

A fine concentrate (20-mesh) from brass-furnace ashes, obtained in the manufacture of an alloy of 80 per cent copper and 20 per cent zinc, analyzed 71.0 per cent copper and 14.3 per cent zinc, the balance being ash, etc. After melting in the furnace 99 per cent of the copper and 50 per cent of the zinc in the concentrate were recovered. This material is usually sent to the smelter and refined in a reverberatory furnace, not all of the copper and none of the zinc being recovered.

Yellow brass ingot (25 per cent zinc) was remelted with 0.5 per cent loss. Red brass (10 per cent zinc), made from red gates, scrap copper, yellow chips, lead and tin, was melted with 0.5 per cent loss.

Heavy German silver scrap (18 per cent nickel, 56 per cent copper, 26 per cent zinc) which gave 1.8 per cent loss on commercial melting in coke fires was melted with 1.2 per cent loss.

Sound copper castings were made from metal melted in the furnace.

Red brass of 81½ per cent copper, 8½ per cent zinc, 6 per cent lead, 4 per cent tin, made from red and yellow ingot and scrap copper, was melted in one series of tests with the following results, the furnace being cold at the start.

TABLE 1.

Heat No.	Weight of Charge, Lb.	Time Arc Was On, Minutes	Pouring Temp., °C.	Kw.-Hr. Used	Kw.-Hr. per 100 Lb.
L 34	127 3	57	1,140	40	30¼
L 35	127 75	50	1,180	30½	25
L 36	128. 5	50	1,220	26½	20½
L 37	126. 5	37	1,220	22½	17¾
L 38	129. 5	36	1,220	19	14¾
Total	639 55	Av. 46	Av. 1,200	Total 138¾	Av. 21¾

The total elapsed time for the five heats, including charging and pouring, was 5 hours; 630.9 lb. ingot poured and 7.45 lb. metal from spillings, etc., recovered, giving a gross metal loss of 1.35 per cent and a net loss of 0.2 per cent.

The power consumption, at the rate of 430 kw.-hr. per ton on a five-hour run, starting from the cold, and at the rate of 295 kw.-hr. per ton when the furnace is hot, with the metal heated to 1200 deg. C, is surprisingly low for so small a furnace.

The results above show that the rocking furnace is a type capable of giving low metal loss and low power consumption. When the furnace was not rocked while melting alloys high in zinc, pressure built up within the furnace and zinc losses were high.

Description of Commercial Furnace

The laboratory tests having demonstrated the probable usefulness of the type, a furnace of commercial size was designed.

The Detroit Edison Company had long been interested in electric brass furnaces as a possible outlet for electric power, and offered to co-operate by constructing a rocking furnace for commercial test without expense to the Bureau of Mines except for the salaries and expenses of its representatives while supervising the test.

Sketches of the furnace design were given the Detroit Edison Company, which refined the design, made the working drawings, constructed and erected the furnace. Two views of the furnace are shown in accompanying illustrations.

The drum is 5 feet in diameter by 5 feet long. The lining is 12 in. thick, and consists of Sil-o-cel brick on the outside, special heat-insulating brick in the middle layer and corundite brick (a very refractory firebrick high in Al_2O_3) in the actual hearth lining. The hearth is 3 feet long by 3 feet in diameter, taking charges of 1300 lb. and upwards. The electrodes are 4 in. diameter graphite, threaded for continuous feed, and are adjusted by screw-operated supports of the lathe-slide type. Single-phase, 60-cycle current, stepped down to 120 to 130 volts is used, 30 kva. being available. Electrode adjustment is by hand, and, to stabilize the arc an external reactance is used which brings the power factor of furnace plus reactance, measured at the furnace switchboard, to about 85. The open circuit voltage falls to about 106 to 116 volts under load. The current varies between 1000 and 2000 amperes, 1650 amperes being about the average. The power input can be varied by altering the length of the arc, and runs from 100 to 200 kw. averaging about 165 kw.

The flexible leads and the water hose for electrode cooling are given slack to allow rocking the furnace, as is clearly shown in Fig. 1.

The rocking of the furnace during melting is done automatically by means of a control device which can be set to give a "safe rock" of 80°, the limit of motion being such that the metal just does not run into the spout. After the charge has begun to melt, the "safe rock" is started. It is called the "safe" rock because the angle is such that solid charge will not fall on the electrodes and break them. A complete oscillation on safe rock takes 13½ seconds.

During the safe rock the solid metal is swashed about in the molten part of the charge and is tumbled over, so that fresh surfaces receive direct radiation from the arc. As melting goes on, the rocking angle is increased by turning the handle of the control device from time to time, until, when the metal is all melted, the furnace is on the "full rock" of about 200°. On full rock the metal washes the whole circumference of the hearth save the height of the charging door and a few inches above and below it, so that metal does not splash into the door joint. A complete oscillation takes 53½ seconds.

The reversal of the 5-hp. motor at either end of the rocking angle is done by contactors, operated by solenoids actuated by the contacts on the control device.

When it is desired to depress the spout past the limiting point of the automatic rock, for pouring, the control device is switched out and the solenoids are operated by a reversing switch.

Comparison with Coke-fired Furnaces

The furnace is installed at the plant of the Michigan Smelting and Refining Company, Detroit, Michigan, which makes brass ingot to customers' specifications from chips, scrap and junk of various kinds, by means of strict chemical control. As the firm makes no sand castings, but ingot only, no observations were possible on the comparative quality of metal melted in the electric furnace and in the coke fires. All the metal melted was poured into ingot which went into the regular output of the plant. As far as could be told by analysis and appearance, the electrically melted metal was of at least as good a quality as that from the coke fires. On alloys high in lead there was somewhat less segregation than in the metal melted in crucibles, and on charges high in zinc, the zinc content of the metal from the electric furnace was higher than that from the same charges melted in the coke fires.

As there is generally much oil on the borings and some non-metallic material in the other scrap, the true metallic content of the charge is seldom accurately known. Hence the net metal losses cannot be exactly determined.

The metal losses were therefore compared with those of the coke-fired crucible furnaces operating on the same charge.

From 102 tons of metal melted in strict comparison with the crucible furnaces, the rocking electric furnace produced 3626 lb., or 1.8 per cent more metal from the same charge than did the coke fires. The alloys melted ran from 90 per cent to 66 per cent copper, 1 per cent to 9 per cent tin, 1½ per cent to 26½ per cent lead, 0 to 50 per cent zinc.

The comparative metal losses on a few alloys in the electric and the coke fires are given in Table II

TABLE II

Composition Per Cent				Weight Charged, Lb.	Per Cent Loss (Metal, Oil and Dirt) Coke Fires	Per Cent Loss (Metal, Oil and Dirt) Electric Furnace
Cu	Sn	Pb	Zn			
85	5	5	5	6,576	4 6	3 2
84	7	4	1	11,600	7 0	3 7
84	6	10	0	14,300	2 4	1 8
79	9	10	2	11,790	3 6	2 1
78	2	10	10	15,840	7 1	3 1
76	8	13	3	11,605	4 0	2 4
73	4	20	3	14,392	3 7	2 9
67½	4	26½	2	5,224	3 0	2 4
67	1	2	30	7,200	8 0	5 1

TABLE III

Per Cent	Copper	Tin	Lead	Zinc
Sought	76 0	8 0	13 0	3 0
Electric	75 9	8 3	13 1	2 7
Sought	76 0	8 0	13 0	3 0
Electric	76 2	8 0	12 4	3 2
Sought	85 0	5 0	5 0	5 0
Electric	85 2	4 9	4 8	5 0
Sought	83 0	4 0	6 0	7 0
Electric	82 9	4 4	5 7	6 9
Sought	67 0	1 0	2 0	30 0
Electric	66 6	1 0	2 0	30 4
Coke	68 4	0 5	1 7	29 3
Sought	68 0	1 0	7 0	24 0
Electric	67 9			
Coke	69 9			

The rocking furnace gave alloys that analyzed very close to the calculated analysis, especially if the difficulty of calculating the analysis of a scrap charge is considered. Characteristic analyses are given in Table III.

There was no difficulty in draining the metal completely from the hearth, and alloys of different composition could be made one after the other without contamination by metal remaining from the previous heat.

The power consumption on 10-hour operation, with no night heating is shown in Table IV, which gives a résumé of 5 days operation.

The power consumption on 24-hour operation is shown in Table V, for a 4-day run.

In the 24-hour tests tabulated in Table V and in a 10-hour run just preceding, in which the 75½ Cu, 7½ Sn, 14½ Pb, 3 Zn alloy was melted, the charge was as follows:

Ingot	25,200 lb
Red borings	11,200 lb 2 [illegible] 224 lb
Medium brass	4,540 lb
Scrap Cu	10,987 lb
Ingot Cu	552 lb
Ingot Pb	3,906 lb
Yellow borings	1,400 lb 3 [illegible] 42 lb
	54,835 266

For the 86 Cu, 6 Sn, 10 [illegible]

Ingot	16,000 lb
Cu	4,704 lb
Pb	[illegible]
	20,800
Total charge	75,635
	266
	75,369

There was obtained:
53,841 lb. [illegible] 75½ Cu
20,149 lb. [illegible] 86 Cu

73,990 lb. total [illegible] 1,379 lb. [illegible] 1.8 per cent
63 lb. scrap 7½ Cu
43 lb. scrap 86 Cu
300 lb. [illegible] 7½ Cu 53 per cent
130 lb. [illegible]

365 lb. [illegible] 429 lb. [illegible]

74,891 lb. [illegible] 44 [illegible]

On the basis of power read on the high-tension side of the transformer, per ton of metal poured, 536 kw.-hr. per ton, on red brass poured at 1180 deg. C. average temperature. For 24-hr. operation the figure is about 260 kw.-hr. per ton for red brass.

The electrode consumption was 16.3 lb. while melting 21660 lb. of metal, or 1.5 lb. per ton, equivalent to about

40 cents at present electrode prices. To this must be added the loss due to accidental breakage. There were nine breakages in melting 72 tons, four of which were due to the charge being so bulky that it fell against the electrodes when rocking started, and five to the electrodes being hit, while bulky material was being charged. The design of the furnace has now been altered so as to allow the electrode tips to be withdrawn into the walls during the charging of bulky material. When an electrode does break, if nipple joints are used, the breakage is usually of the nipple only.

Since the operation was experimental, it is not yet possible to give exact figures on the life of a lining, but as near as can be estimated the relining cost for labor and material should be well under 50 cents per ton with a corundite lining when melting red brass poured at 1150-1200 deg. C. If only yellow brass, poured at 1100 deg. C. is melted, the lining cost will be still lower. If very hot bronze is to be produced, say at 1300 deg. C., the roof and upper portions of the ends should be lined with zirkite brick.

Advantages of Rocking Furnace

Accurate temperature control is very easy in the rocking furnace, since at the end of a heat, after the "full rock," the walls are no hotter than the metal, and there is no heating up of the charge from hotter roof and walls when the power is shut off, as is the case with those types of furnace where the heat is reflected downward from the roof. After cutting off the arc, the temperature falls very slowly, about 2 or 3 deg. C. per minute. By running the arc a minute or so every 10 or 15 minutes, a charge can be held at pouring temperature for an indefinite period.

One man can operate the furnace, with the aid of a helper while charging. Were automatic electrode con-

TABLE IV

Date	Heat No.	Alloys Cu	Sn	Pb	Zn	Nature of Charge	Pounds Charge	Elapsed Time	Sec. Kw.-Hr. Arc	Kw.-Hr. Motor	Total Sec. Power	Pouring Temp.	Weight Poured	Primary Kw.-Hr.	Secondary Kw.-Hr. Cwt. Charged	Primary Kw.-Hr., Cwt. Poured	Remarks
Nov. 5	192	85	5	9	1	Average	1314	3:40	257	4	261	2000°F. / 1095°C.	.....	.....	20.0	....	Furnace cooler than usual, not run previous two days. No. 192 includes 1 hr. 20 min., 100 kw.-hr. preheat
	193	85	5	9	1	Average	1314	1:50	219	3	222	2050°F. / 1120°C.	.....	.....	17.0	....	
	194	79	9	10	2	Little bulkier than average	1304	1:35	196	2	198	2125°F. / 1165°C.	.....	.....	15.0	....	
	195	79	9	10	2	Little bulkier than average	1304	1:30	190	2	192	2200°F. / 1205°C.	.....	.....	14.5	....	
	196	79	9	10	2	.....	1304	1:40	190	3	193	2200°F. / 1205°C.	.....	.....	15.0	....	Time includes 20 min. charging heat 197
Day total, 5 heats							6540	10:15	1052	14	1066	2115°F. / 1155°C.	6360	1162	16.3	18.3	
Nov. 6	197	79	9	10	2	Little bulkier than average	1304	1:45	235	3	238	2125°F. / 1165°C.	.....	.....	18.5	....	
	198	79	9	10	2	Little bulkier than average	1304	1:30	199	3	202	2175°F. / 1190°C.	.....	.....	15.5	....	
	199	79	9	10	2	Little bulkier than average	1304	1:40	186	2	188	2250°F. / 1230°C.	.....	.....	14.5	....	
	200	79	9	10	2	Little bulkier than average	1304	1:40	176	2	178	2240°F. / 1225°C.	.....	.....	13.5	....	
	201	79	9	10	2	Little bulkier than average	1304	1:30	162	2	164	2100°F. / 1150°C.	.....	.....	12.5	....	
	202	79	9	10	2	Little bulkier than average	1304	1:45	160	2	162	2125°F. / 1165°C.	.....	.....	12.5	....	Time includes 20 min. charging heat 203
Day total, 6 heats							7824	9:50	1118	14	1132	2185°F. / 1195°C.	7571	1236	14.7	16.3	
Nov. 7	203	79	9	10	2	Little bulkier than average	1304	1:35	215	3	218	2125°F. / 1165°C.	.....	.....	17.0	....	
	204	79	9	10	2	Little bulkier than average	1304	1:40	195	2	197	2165°F. / 1185°C.	.....	.....	15.0	....	
	205	79	9	10	2	.....	1304	1:30	180	2	182	2175°F. / 1190°C.	.....	.....	14.0	....	
	206	79	9	10	2	.....	1304	1:35	173	2	175	2140°F. / 1170°C.	.....	.....	13.5	....	
	207	84	6	10	0	Very bulky	1304	1:40	165	2	167	2150°F. / 1175°C.	.....	.....	13.0	....	
	208	87½	5	½	7	Very bulky	1304	2:30	178	3	181	1950°F. / 1065°C	.....	.....	14.0	....	Includes 50 minutes delay by broken electrode broken in charging bulky charge, also 20 minutes charging heat 209
Day total, 6 heats							7824	10:30	1106	14	1120	2120°F. / 1160°C.	7583	1210	14.4	16.0	
Nov. 8	209	84	6	10	0	Very bulky	1300	3:00	246	2	248	2050°F. / 1120°C.	.....	.....	19.0	....	Time includes 1 hr., 10 min. delay due to broken electrode due to bulky charge. Long delay due to nipple being over-size and requiring to be filed down
	210	84	6	10	0	Very bulky	1300	1:40	198	3	201	2175°F. / 1190°C.	.....	.....	15.5	....	
	211	84	6	10	0	Very bulky	1300	2:05	188	2	190	2175°F. / 1190°C.	.....	.....	14.5	....	Includes 25 min. adjusting electrode holder
	212	84	6	10	0	Very bulky	1300	1:30	169	3	172	2175°F. / 1190°C.	.....	.....	13.5	....	
	213	84	6	10	0	Very bulky	1300	1:50	170	1	171	2175°F. / 1190°C.	.....	.....	13.0	....	Includes 20 min. charging No. 214
Day total, 5 heats							6500	10:05	971	11	982	2150°F. / 1175°C.	6341	1069	15.1	16.9	
Nov. 9	214	84	6	10	0	Very bulky	1300	1:45	223	4	227	2175°F. / 1190°C.	.....	.....	17.5	....	
	215	84	6	10	0	Very bulky	1300	2:05	198	3	201	2200°F. / 1205°C.	.....	.....	15.5	....	
	216	84	6	10	0	Very bulky	1300	1:00	195	2	197	2160°F. / 1180°C.	.....	.....	15.0	....	
	217	84	6	10	0	Very bulky	1300	1:45	189	3	192	2250°F. / 1235°C.	.....	.....	14.5	....	
	218	84	6	10	0	Very bulky	1300	1:25	165	2	167	2150°F. / 1175°C.	.....	.....	13.0	....	
Day total, 5 heats							6500	8:50	970	14	984	2190°F. / 1200°C.	6407	1073	15.2	16.7	

trol used, which could easily be done, one man could probably attend to two furnaces.

The output per man-hour was greater from the rocking furnace than from the coke fires. The working conditions are much less severe and more healthful with the electric furnace than with the coke fires, and a man of less rugged physique than is required for coke fires can readily operate the rocking furnace.

Various modifications and improvements in design were made during the tests, and others that could not well be made on the first furnace are being incorporated in other furnaces of this type now being built for Detroit firms. The electrodes were at first introduced into the furnace directly through the refractory walls. When making yellow brass from new materials so that addition of much spelter is required, the zinc, vaporized during the addition of the spelter to the molten charge, tended to condense in the clearance between the electrode and the hole through which it entered. This would then freeze, solder the electrode in place and cause breakage. Such trouble was later obviated by the use of graphite sleeves about the electrodes and by the proper arrangement and operation of the electrode coolers. It was also found feasible to charge the zinc with the rest of the charge instead of speltering at the end of the heat.

Comparative Costs and Power Consumption

Comparing the cost of melting on a 10-hour schedule in the rocking electric furnace and in the coke fires of

TABLE V POWER CONSUMPTION ON 24-HR OPERATION

Date	Conseq. Heat No.	Day Heat No.	Weight of Charge Lb.	Alloy Per Cent Cu	Sn	Pb	Zn	Elapsed Time Hr.	Min.	Melting Time Hr	Min.	Kw.-Hr Arc Plus Rocking Motor Read on Secondary Side	Equiv Kw.-Hr on Primary Side	Pri Kw.-Hr per Ton Charged	Remarks
Apr. 30	261	1	1,305	75½	7½	14½	3	2	9	1	47	229			Started at 6 30 a.m. Furnace idle since 4 30 p.m. Apr. 29
	262	2	1,305	75½	7½	14½	3	1	53	1	28	192			
	263	3	1,305	75½	7½	14½	3	1	55	1	22	168			
	264	4	1,305	75½	7½	14½	3	1	44	1	15	152			
	265	5	1,305	75½	7½	14½	3	1	44	1	15	144			
	266	6	1,305	75½	7½	14½	3	2	12	1	2	141			
	267	7	1,305	75½	7½	14½	3	1	30		55	153			30 min (included in elapsed time), adding electrode sections and taking new grips
	268	8	1,305	75½	7½	14½	3	1	35		58	156			
	269	9	1,305	75½	7½	14½	3	1	41	1		151			
Midnight	270	10	1,305	75½	7½	14½	3	1	33	1	2	146			
	271	11	1,305	75½	7½	14½	3	1	33		59	143			
	272	12	1,305	75½	7½	14½	3	1	47	1	6	149			
	273	13	1,305	75½	7½	14½	3	2	1	1	2	153			18 min (included), replacing broken electrode nipple, heat ended 5 40 a.m.
Day total,			16,965					23	17	15	11	2,074	2,270	268	
May 1	274	1	1,305	75½	7½	14½	3	2	11	1	18	143			36 min (included) wait for helpers to pour metal
	275	2	1,305	75½	7½	14½	3	1	49	1	12	147			
	276	3	1,305	75½	7½	14½	3	1	40	1	7	152			
	277	4	1,305	75½	7½	14½	3	1	35		55	147			
	278	5	1,305	75½	7½	14½	3	1	45	1	12	142			
	279	6	1,305	75½	7½	14½	3	3		1	20	160			1 hr 10 min (included) replacing broken electrode and altering cooling coil
	280	7	1,305	75½	7½	14½	3	1	32	1	2	151			
	281	8	1,305	75½	7½	14½	3	1	21		57	146			
	282	9	1,305	75½	7½	14½	3	1	19		53	145			
	283	10	1,305	75½	7½	14½	3	1	23		55	151			
Midnight	284	11	1,305	75½	7½	14½	3	1	31		56	152			
	285	12	1,305	75½	7½	14½	3	1	34	1	1	152			
	286	13	1,305	7 [illegible]	7½	14½	3	1	20		48	141			
	287	14	1,305	7 [illegible]	7½	14½	3	1	33		53	147			
Day total,			18,270					23	35	14	27	2,076	2,272	249	
May 2	288	1	1,305	75½	7 [illegible]	14½	3	1	35	1	5	150			Heat started at 6 35 a.m. Furnace idle [illegible] 25 min between shifts
	289	2	1,305	75½	7 [illegible]	14½	3	1	25		52	145			
	290	3	1,305	75½	7 [illegible]	14½	3	1	23		57	143			
	291	4	1,305	75½	7 [illegible]	14½	3	1	[illegible]		55	144			
	292	5	1,305	75½	7	14½	3	1	35	1	7	144			
	293	6	1,305	75½	7	14½	3	1	39		56	141			Motor relays in position for best connections
	294	7	1,300	84	6	10	0	1	31	1	04	140			
	295	8	1,300	84	6	10	0	1	18		50	150			Furnace [illegible] 45 [illegible] 294 [illegible] 1,295
	296	9	1,300	84	6	10	0	1	48		59	158			
	297	10	1,300	84	6	10	0	1	22		52	151			
	298	11	1,300	84	6	10	0	2	13	1	5	156			39 [illegible]
Midnight	299	12	1,300	84	6	10	0	1	28		59	162			
	300	13	1,300	84	6	10	0	1	37	1	10	179			
	301	14	1,300	84	6	10	0	1	49	1	12	163			[illegible] 5 20 a.m.
Day total,			18,230					22	05	13	59	2,126	2,318	254	
May 3	302	1	1,300	84	6	10	0	1	43	1	14	167			[illegible] 6 40 a.m. [illegible]
	303	2	1,300	84	6	10	0	1	43	1	22	158			[illegible] 1 [illegible] 302 [illegible]
	304	3	1,300	84	6	10	0	1	55	1	9	158			[illegible] [illegible] 303 [illegible] 304 [illegible] [illegible]
	305	4	1,300	84	6	10	0	1	44	1	17	159			
	306	5	1,300	84	6	10	0	1	59	1	16	166			[illegible] [illegible] 304 [illegible] 1 [illegible]
	307	6	1,300	84	6	10	0	1	35	1	10	162			
	308	7	1,300	84	6	10	0	1	23	1	10	162			
Midnight	309	8	1,300	84	6	10	0	2	15	1	5	165			42 [illegible] Brass 2 [illegible]
	310	9	1,305	75½	7	14½	3	1	19		55	152			
	311	10	1,305	75½	7	14½	3	1	14	1		140			
	312	11	1,305	75½	7	14½	3	1	21		50	142			
	313	12	1,305	75½	7	14½	3	1	36	1	13	144			[illegible] 5 [illegible]
Day total,			15,620					19	38	13	41	1,875	[illegible]	[illegible]	
4-day total,			69,085												

the plant at which the test was made, the sum of the cost per ton of charge for electric power, interest and depreciation, electrodes, linings, and for heating ladles, is just about one-half of the cost per ton of charge of the single item of crucibles at present prices and at present crucible life. The value of the metal saved by the electric furnace is about twice the cost of the coke used by the coke fires. Hence a huge saving is possible by electric melting under present conditions; and even at pre-war prices for crucibles, coke and metals, the rocking furnace will show a smaller, but still a distinct, saving. On 24-hour operation the balance in favor of electric melting is still more marked.

From data on hand on the power consumption of other types of electric furnaces, it appears that, when operated on the same alloy, heating it to the same temperature, and running the same number of hours per day, the rocking furnace is somewhat more efficient than the direct-arc and un-rocked indirect-arc types, very much more efficient than electric furnaces of types in which heat is reflected onto the charge from the roof, and very little less so than the induction furnaces. These conclusions follow not only from the data at hand, but from the method of application of heat in the various types, those with the source of heat at a distance from the charge being less efficient than those where the heat is developed close to the charge; the induction furnaces in which the heat is developed in the charge itself should be the most efficient. On account of the washing of the walls with the metal, the rocking furnace should theoretically come next to the induction type in thermal efficiency.

Comparative Metal Losses

In magnitude of metal losses, the rocking furnace gives at least as good results as any other type of electric furnace. The only possible loss is from the stream of metal while pouring, as the furnace is sealed tight while running. Volatilization from the stream while pouring is of course about the same in all types of furnaces.

In closeness of control of the temperature of the melt the rocking furnace is superior to any save the induction type. In thorough mixing of the charge, the rocking type is about on the same plane as the induction type, and markedly superior to the other types, where, in large sizes, segregation in the bath may be a serious problem. For example, the following shows the analysis for copper of the first ingot from the first ladle and of the last ingot from the last ladle when melting 1200-lb. charges of 60 per cent Cu, 37 per cent Zn, 3 per cent Pb.

Heat	First Ingot, First Ladle	Last Ingot, Last Ladle
322	59 76% Cu	59 54% Cu
323	59 78% Cu	59 66% Cu

In ability to change from one alloy to another, it is superior to the vertical-ring induction type; and in ability to operate cheaply when used but 10 hours a day, without night heating, it is ahead of the vertical-ring induction type and of the reflected-heat types.

The rocking furnace can handle alloys of any zinc or lead content, being superior on this score to direct-arc, unrocked indirect-arc and induction types. The electrode cost compares favorably with other arc furnaces. With equal conditions of operation, and suitable refractories in each type, the cost of lining will probably be about the same as with most other types. Labor cost should be about the same in all hand-regulated arc furnaces. With automatic regulation, which can be applied if desired, the rocking type should show a labor cost about the same as that of any other type.

Load With Rocking Furnace Not So Steady As With Induction Type

From the electrical point of view, of desirability of a steady load, the rocking furnace does not have so steady a load, and hence, on this score, is not so desirable as the induction furnaces or granular resistor furnaces. It does not require special transformers, as the granular resistor type does. It lacks the electrical advantages of multiphase furnaces. In very large sizes, two arcs could be used in the rocking type, but in sizes up to one ton, single-phase operation is required, and in a plant so located that the power supply must be of limited capacity, a single-phase arc furnace, with its fluctuating loads, may not be satisfactory from the electrical point of view. Such fluctuation is no drawback in Detroit nor would it be in most cities or large manufacturing towns.

From the results on furnaces of 125 and 1300 lb. capacity, it appears that the rocking type can be built in a wide range of sizes without showing a great loss of efficiency in the smaller sizes. This type can doubtless be built in as large sizes as the brass industry could normally use.

In first cost, the rocking type should be no more expensive than other electric furnaces.

While further tests in different plants and under different conditions, which will, at least in part, be made in the near future, are neded to give accurate data on the complete performance of the rocking type of furnace, it would seem from the results so far that it may be of distinct value in the brass industry, especially under present conditions as to crucible prices and quality, fuel supply and prices, and metal prices.

At the conclusion of the tests conducted by the Bureau of Mines, which covered over 300 heats, the experimental furnace was put on regular production by the Michigan Smelting & Refining Co. Four one-ton rocking furnaces are being built for this company and two for the Electro Bronze Co.

Licenses to Make Furnace Granted by Bureau of Mines

The patents taken out by the Bureau of Mines on the rocking furnace have been assigned to the Secretary of the Interior as trustee, and free licenses to operate under them can be obtained by making application through the Director of the Bureau of Mines.

Grateful acknowledgement is made to Cornell University for use of the well-equipped Cornell electric furnace laboratory in the work on the laboratory furnace; to Dr. J. M. Lohr, formerly of the Bureau of Mines, for aid in the work on the laboratory furnace; to the Michigan Smelting and Refining Company for facilities for the test, and to the Detroit Edison Company, and particularly to Mr. E. L. Crosby of the latter firm, for never-failing co-operation.

A more detailed account of the tests of the rocking furnace will soon be published as *Bulletin* 171 of the Bureau of Mines.

The Miles Acid Process for Sewage Disposal

Sewage Disposal Is a Problem in Chemical Engineering to Show How to Use Waste Materials. Tests of a New Chemical Process in Connecticut

SEWAGE disposal is really a municipal problem, and as such there is often the hazard that it may become either Republican or Democratic. When this occurs the best thing for the enquirer to do is to wander away somewhere else for his research, because when politics gets mixed up with it the pollution is likely to become too great even for sewage to endure.

Everybody knows that the situation, as it exists today in regard to municipalities in America is about as bad as it can be, this side of epidemics. In New York Harbor along the Brooklyn shore line there are places where the water is not changed by the tide, where it lacks oxygen and where, in sludge deposits on the bed of the river, a septic condition has arisen. This invites disease and we also know that disease will not refuse an invitation of that sort if there is perseverance in the bidding. Chicago needs more water from the Lake to carry its wastes down the drainage canal, and Uncle Sam seems to be of opinion that Lake Michigan hasn't any more water to spare to hasten Chicago sludge down the Mississippi River. New Haven, Conn., was cautioned by U. S. Government engineers that the harbor was becoming polluted with sewage, and that fishing for oysters must stop. Prof. C. E. A. Winslow of Yale University is now making comparative tests there, to which we shall refer at length later. Boston Harbor is receiving rather more than it can care for without offense to those that go down to the sea in ships and those that live along the shore.

The problem has become one for chemical engineers. The sanitary engineer has looked for and found places where sewage may be put until, so to speak, the places have become all filled up. So it is up to the chemist to find uses for sewage that are at once sanitary and economical, and thus to make it pay back some of the money it costs to get rid of it.

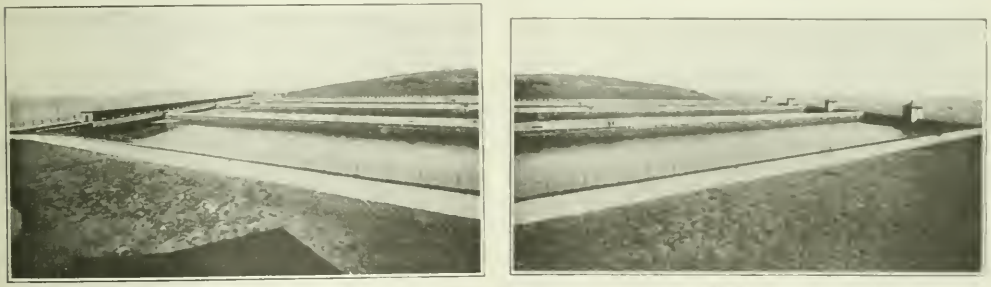
Activation seems to point out a way provided it may be carried far enough. The bacterial action seems to digest most of the polluting material and, under proper control, the effluent may be made crystal clear. The sludge, with fats reduced to 5 per cent or less is proved to be good fertilizer. The cost of installation is, unfortunately, pretty high.

Imhoff tanks get a great deal of the suspended matter from sewage and the effluent may be chlorinated and thus made reasonably safe. The sludge which is saved however, is both offensive and so far, nearly useless. It must be disposed of, and farmers do not seem to care for it.

Outline and Claim of the Miles Process

The acid treatment of sewage discovered and patented by George W. Miles, a Boston chemist, is very promising, and has been the subject of considerable discussion of late. In response to efforts made to establish a municipal sewage recovery plant in Boston a committee was appointed by the Massachusetts legislature to examine the merits of the proposal. In January of this year it made a report adverse to this and other known processes. The committee used bottles for their experiments, and their report is only worthy of interest because it shows the prejudice still to be found in the official mind. One of the special claims for the Miles process is the rapid sedimentation after acid treatment, 4 hours being held to be sufficient for this purpose in practice. The committee in their comparative tests in bottles allowed 18 hours for sedimentation and then drew their conclusions. Experiments of this sort shed darkness rather than light. Their main reason why it was recommended not to establish a recovery plant was because for many years in England, France and elsewhere, efforts to recover and use sewage have been unsuccessful! "Millions for Appropriations but Not One Cent for Research," might well be inscribed upon the City Hall of many an American municipality.

We offer the present record of the Miles process made up chiefly from statements of the inventor and his associates and from data which they have provided. We have also visited a 10,000-gallon test plant at New Haven, Conn., and we shall give a report of its operation at the conclusion. The subject is by far too important to neglect, inasmuch as, according to the claims



VIEWS OF FOUR SEDIMENTATION TANKS OF 12,500,000 GALLONS CAPACITY EACH IN BOSTON HARBOR, PROVIDING AN OPPORTUNITY TO TEST THE MILES ACID PROCESS ON 100,000,000 GALLONS DAILY

of the inventor, an actual solution of the sewage problem is provided, while most of the studies made so far indicate a confirmation rather than a denial of his claims. The claims are in effect as follows: That by treating sewage with SO_2 or with nitre cake in the proper proportion, the soaps are broken up, 98 per cent of the grease is removed and recovered while the resultant sludge is not only inoffensive but an efficient low-grade nitrogen fertilizer; that the effluent is also clear and inoffensive and effectively sterilized; that plants may be established and operated without producing evil odors or unwholesome or unpleasant effects upon the immediate surroundings; that the materials recovered may be sold for enough to pay a fair return on the investment instead of being a tax upon municipalities; and that nothing escapes from the sewers into rivers, harbors or sinks but the sterilized effluent. Indeed, where irrigation is practicable, the effluent, which was found to contain 1000 lb. K_2O, 70 lb. P_2O_5, 120 lb. total organic nitrogen and 1.83 lb. nitrogen as ammonia per million gallons, may be run over limestone and used for irrigation. The excess acid in it was found to be only 30 parts per million.

Municipal sewage, as it emerges from the sewer, is fluid, cloudy and has a slight odor, although the process of fermentation is beginning. On evaporation it yields chiefly ammonia, glycerides, soap and nitrogenous materials. It contains also potash and phosphates, but the potash is mostly lost in the effluent in the Miles process.

Treatment with Sulphur Dioxide

The process provides that at the receiving tanks at the mouth of the sewer, a small portion of the sewage be pumped through an absorption tower with a counter current of SO_2. This SO_2-saturated sewage is run into the main sewer some distance back of its mouth so as to provide for thorough mixing. It flows at low velocity into a settling tank and by a continuous process into a second settling tank from which the effluent flows off. The size of the tanks must be such as to allow four hours for sedimentation in each series of two or more. During the four hours all but two per cent of the solids recoverable by settling are precipitated. The sludge collects at the bottom of the tanks but it is not removed daily. It is desired that it pack down, and to that end it is proposed to operate each series for several days to a week at a time before switching over to a duplicate series of collecting tanks. In tests made, no putrefaction occurs under these conditions. After the liquid is drawn from the settling tanks, the sludge which is pumped out contains 80 to 92 per cent of water, depending upon the method of treatment and the character of sewage.

From experiments made by Professor Robert Spurr Weston of the Massachusetts Institute of Technology on Boston sewage it was concluded that 1963 lb. of SO_2 is required to treat 1,000,000 gallons of sewage. That is roughly, a ton to the million gallons. That would require ½ short ton of sulphur or about one long ton of pyrites to produce the desired effect. Nitre cake may also be used for the purpose of breaking up the soaps, but in that event it is necessary to add a slight excess of SO_2 to stop and prevent fermentation. That is, it was determined by experiment that 3.82 tons of nitre cake was required with 200 lb. SO_2 to treat 1,000,000 gallons of sewage. The result is 1909 lb. of dried sludge, with 430 lb. of fats, according to Professor Weston. The Massachusetts Joint Commission in its adverse reports said that they had made "shorter" experiments which indicated 1427 lb. of dried sludge and 542 lb. fats per million gallons. Of course, neither the sludge nor grease is present in constant proportion but in tests made by Mr. E. S. Dorr of the Sewer Division of the City of Boston from June, 1911, to June, 1914, at frequent intervals there was found in Boston sewage an average of 1914 lb. sludge per million gallons, of which 22.33 per cent was grease by SO_2 precipitation.

The recovered sludge is like greasy, brown or grey mud. It has no odor and even after ten days in hot weather it lacks the offensiveness that it would have immediately acquired without treatment. It has rather a slight mouldy smell if kept too long before degreasing.

Sedimentation of Sludge in Series of Tanks

When the standing liquor has been drawn off and the sewage turned into one of the duplicate series of two or more settling tanks then in operation, the sludge is allowed to drain for a period, and then it is pumped up and, as the season favors, there may be partial air-drying. The final drying must be done under careful temperature regulation to prevent burning. The gases are not offensive and contain no NH_3.

The next process is the solvent extraction of grease from the sludge, which leaves a finely divided, practically grease-free fertilizer material containing 4½ per cent NH_3 and between 1 and 2 per cent P_2O_5. Whether this is economical is a problem in chemical engineering.

This freedom of the sludge from grease is important. It is claimed that sewage farming has generally failed because of the presence of soap and grease which clog the soil and make it "sick." When lime or copperas is used, as is frequently done, the sludge contains insoluble soaps and the value of the fertilizer is not developed. In this process it will be observed that the very first operation is to disinfect the sewage, remove the odor and break up all the soaps before the mouth of the sewer is reached, or as the sewage runs into the first settling tank. The chemical treatment, except the grease extraction, is completed in the very first step.

Commercial Value of Products

In 1913 the Amherst, Mass., Agricultural Experiment Station valued this dried, grease-free fertilizer at $15 to $16 per ton, and announced that over half the nitrogen content was in form to be valuable the first year. The value of nitrogen fertilizer has lately been quoted at $6.50 per unit of ammonia, which would make this which contains 4½ per cent NH_3, $29.25 per ton. It is either a low-grade fertilizer or a fertilizer base, to which tankage, phosphates and other ingredients may be added. Being in a very finely divided condition it should add humus to the soil. Tests for phosphoric acid showed from 1.2 to 1.6 per cent, while K_2O was present only to the extent of 0.03 to 0.14 per cent in the sludge.

The grease produced by extraction consists of glycerides and free fatty acids in the proportion of about half and half. It compares, according to the inventor, with garbage grease. It was worth about 4½ cents per pound at pre-war prices. Since then it has been quoted as high as 15 cents.

One million gallons of sewage at Moon Island, Boston Harbor, produce about 400 lb. of recoverable grease. This sewer, therefore, delivers to the tide, with its 100,000,000 gallons per day, 40,000 lb. of grease. That would indicate, assuming half the grease to be in the form of glycerides, a waste of one ton of glycerine besides 68 tons of fertilizer from this one sewer that now corrupts the harbor with the drainage of about 600,000 inhabitants.

Moisture and Fiber Are Obstacles

The great difficulty lies in the enormous quantity of water that must be evaporated and the fact that 15 to 40 per cent of the sludge is crude fiber. It balls up, and in a steam dryer it will cake and insulate the tubes. In this connection a patent has lately been granted to Mr. Walter H. Sawyer, of Lewiston, Me., who is interested in the company, for a screening device to remove the fiber, wash it with effluent, press down to 50 per cent water, degrease and, possibly, use as cheap paper stock. With the fiber removed the sludge may be reduced from 85 or 90 per cent to 67 per cent water, after which it is to be run through a thermal dryer. To get one ton of dry material from 85 per cent aqueous sludge, 11,000 lb. of water must be evaporated, whereas, when the water is reduced to 67 per cent only 4000 lb. needs to be evaporated; therefore the advantage of multiple effect evaporation, which is feasible down to 67 per cent moisture, may be obtained for 7000 lb. of the water for each ton of dry material. The figures are Mr. Sawyer's.

The effluent shows considerable variation in content. Comparative analyses show 1233 lb. K_2O from the North Metropolitan sewer in Boston Harbor and 888 lb. K_2O in that from Moon Island; 52 lb. P_2O_5 per million gallons also was found in the effluent. The acidity ranged from 1 15 to 1 100 of one per cent sulphurous acid. The bacterial count decreased from 4,000,000 per cc. in sewage to 400 per cc. in the effluent, and these were chiefly mould fungi. The New Haven experiments showed less favorable results in this respect, but it will be noted that the SO_2 supply was occasionally short owing to conditions that will be explained.

Estimated Costs and Profit

With the sewage adequately sterilized and deodorized at the beginning a proper installation should insure against pollution. The usual offensiveness would be done away with and such disposal plants might be put up in decent surroundings within the city limits and without danger of offense or disease contagion. The products recovered are of great economic promise and even in normal times should make the disposal of sewage cease to be the present financial and sanitary burdens that it is upon large municipalities. It provides for the metallurgical utilization of low-grade sulphurous ores, the SO_2 fumes from which may be liquified and shipped to the nearest towns. And it provides also for the use of all the niter cake that is produced. The estimated cost, based on present prices for large-scale plants, is $12,000 per million gallons to be treated daily. Mr. Weston computes the cost of acid treatment to be $7 to $9 per million gallons under pre-war conditions. The value of the grease under pre-war conditions he figures at $16 per million gallons and the fertilizer base as $10.20, or $26.20 for both. Under conditions as of Jan. 9 last, with grease at 15 cents per pound and ammonia in fertilizer at $6.20 per unit per ton, there should be $90.91 return per million gallons treated. That would provide under pre-war conditions $26.20 return per million gallons, less say, $9 for acid treatment, leaving $17.20 to defray cost of drying and degreasing the sludge recovered from a million gallons. Under present conditions with a cost of $20 for acid treatment and $90.91 received for grease and fertilizer, there would remain a margin of over $70 for the same purposes and for profit.

Comparative Test of Four Methods at New Haven

The foregoing figures are gathered chiefly from reports made by Professor Weston and Mr. E. S. Dorr of the Boston Department of Sewers. A late journey to New Haven and a conference with Professor C. E. A. Winslow in charge of the municipal experimental plant and Dr. F. W. Mohlman, his assistant, confirmed the above results in part. The problem at New Haven was not one of sewage recovery but rather the removal of 80 to 90 per cent of the settleable solids, the partial clarification of the effluent and disinfection as required. For this purpose tests of four methods were taken in comparative plants placed at the mouth of the East Street sewer which discharges about 13,500,000 gallons daily into the harbor, a total of more than half the sewage of the city of about 160,000 inhabitants. The tests are still in process and the final reports are not yet made, but thanks to Prof. Winslow and Dr. Mohlman we are permitted to give certain results which have been reached already.

The East Street sewer, 63 in. in diameter, carries the wastes of two great munition works, a part of that of a great hardware manufacturing concern and other important industries, and the experiment emphasizes the fact that sewage is a word with very miscellaneous meanings. The presence of considerable copper in solution from one of the munition works cuts down the bacteria count much below that usually found. A considerable amount of mineral oil is present. One factory pumps up large quantities of sea water for a condenser and this runs the test for chlorine from 14 parts per million at 4 a. m. to 2875 parts at 11 a. m. Condenser water and other industrial wastes dilute the sewage far beyond the municipal average.

The comparative tests are made with (1) activated sludge, (2) Imhoff tank, (3) screening, and (4) Miles-acid. The effluent of all except the Miles process is disinfected by chlorine.

Results in Sedimentation and Bacterial Count

The activated sludge process is too expensive for the purpose and the presence of copper from the munition works and other industrial wastes seem to interfere with the biological conditions demanded by it. The Imhoff tanks give good results in regard to clarification. The accumulation of sludge was less than anticipated. The screening tests were not satisfactory and gave a recovery of less than 10 per cent of the solids.

The Miles tank 4 x 4 x 16 ft. cares for 10,000 gallons daily and has been in operation during the last run from January 26. On March 30 it was still going. There is no sludge on the surface, no gas, and no septic condition. Only 700 lb. SO per 1,000,000 gallons is

used, in view of factory wastes. The effluent is satisfactory and it is exceedingly convenient to handle the deodorized sludge. That which has not been degreased has, after 2½ months, only a slight earthy odor.

With the Imhoff tank the average reduction for November, December and January of suspended solids was 46 per cent. and of settleable solids 83 per cent. The bacteria per cc. at 20 deg. C. were 506,700 in the influent and 640,440 in the effluent while the average gas-formers were respectively 14,920 and 10,530.

With the Miles acid process the average of three tests of 25 days in June, 24 days in July and 44 days in November and December showed a reduction of 59 per cent suspended solids, and 87 per cent settleable solids; while the bacteria per cc. decreased from 558,000 in the raw to 8,000 in the effluent, or 98.5 per cent and gas-formers decreased per cc. from 19,860 to 160 or 99.2 per cent. The wet sludge contained 86.9 per cent moisture and there was 3630 lb. wet and 475 lb. dried sludge per million gallons. The ether extract was 26.5 per cent of dry sludge or 121 lb. per million gallons.

In regard to the bacteria it is noted that the pressure of the SO_2 from the pressure tanks which served for the supply varies with the temperature; that occasionally, despite hourly tests, the acidity would get very low and that frequent adjustments of the valves were necessary. The acidity of many samples tested was below 50 parts per million, and if these tests were discarded the bacterial count would be much lower.

It will be observed that this sewage is remarkably dilute, producing but 475 lb. dried sludge to the million gallons against 1909 lb. found in Boston sewage by Professor Weston. The large proportion of fats in the sewage is confirmed, but the quality of the fats present is seriously affected by the mineral oils contributed from industrial sources. Several laboratories now have samples of the grease under examination. In order to study another type of sewage a small tank with 5000 gallons daily capacity is being tested at the mouth of another sewer, which drains houses and several large laundries, but no manufacturing establishments. This sewage requires far more acid and yields grease of a better quality. The results of these studies will not be known for several months.

The New Haven experiment seems to be bringing the available systems down to Miles-acid and Imhoff tanks. The Imhoff tanks leave the sludge still to be disposed of, which is a difficult and septic mess to handle. The chlorination of the effluent is also expensive. Against this there is the Miles process, with inoffensive sludge and the effluent already sterilized. The sludge will probably have no value unless it is degreased and the question then remains whether there is enough fertilizer and enough grease to pay for the plant. The cost of acidulation varies with the alkalinity of the sewage, while the cost of chlorination of Imhoff effluent is less variable. It is, as we observed before, a problem in chemical engineering and, as Professor Winslow (from whom we gathered the idea) says, "The sanitary engineer should have called the chemical engineer into his counsel long ago, for the problem of today is not how to get rid of things so much as it is how to use them." We agree with him entirely.

There is no conclusion to this article, because the work is not finished, and the acid treatment of sewage is still in the promotion stage. What seems to be brought out is that the SO_2 acidulation of sewage is a considerable contribution to the reduction of offense. The cost of plant and operation and the returns that may be expected are variable because no two sewers are precisely alike in their burdens; but all the problems presented are easy to solve by competent chemical engineers, provided always politics do not enter into the sewage and undo all the good that either chlorine or SO_2 can bring about.

Regulations Concerning Exports to Great Britain, Italy and Belgium

THE War Trade Board announces after consultation with the United States Food Administration, the United States War Industries Board, and the Missions of the respective European allies, that for the purpose of preventing the useless consumption of materials and labor in making articles for export which for the present may not be exported, and for the purpose of saving tonnage by prohibiting the exportation of articles which have not been recommended by the Government of the country of destination as being necessary for their essential requirements, the War Trade Board has adopted the following additional rules and regulations with respect to the issuance of licenses to export any commoodity to the United Kingdom, France, Italy and Belgium (excluding their respective colonies, possessions and protectorates).

On and after May 15, 1918, applicants, before filing applications for licenses to export any commodity to the above named countries, must obtain thereon the written approval of the mission in the United States of the country to which the exportation is to be made. To secure this approval, applicants should forward their applications, duly executed, in triplicate, with proper supplemental sheets attached thereto, including Supplemental Sheet X-11 or X-12, as may be required, to:

The British War Mission, Munsey Building, Washington, D. C. For shipments to the United Kingdom.

The French High Commission, 1954 Columbia Road, N. W., Washington, D. C. For shipments to France.

The Italian High Commission, 1712 New Hampshire Ave., N. W., Washington, D. C. For shipments to Italy.

The Belgian Commission, Room 202, Council National Defense Bldg., Washington, D. C. For shipments to Belgium.

One copy of approved applications will be forwarded by the Missions directly to the War Trade Board, Bureau of Exports, Washington, D. C.; one copy retained; and the other copy returned to the applicant for his convenience in keeping a record.

Applicants will be required to agree with the War Trade Board not to purchase nor acquire for export nor take any steps in the process of producing manufacturing or fitting for export the articles specified in the application until an export license has been duly granted.

On the Molecular Physics of Ore Flotation[1]

By WILL H. COGHILL[2] and C. O. ANDERSON

Introductory

IT IS COMMON practice to inquire into the efficiency of a process as soon as it has been made commercially successful. So it has been with the flotation process. Hoover[4] makes an erroneous statement about the force required to penetrate a liquid surface, and with it as a basis calculates and tabulates the actual and theoretical capacities of several types of flotation machines. Other writers have made similar efforts by using principles incorrectly. The most striking case is that of Van Arsdale.[5] He begins with the premise that "the maximum weight that can be supported on the surface of water is equal to the surface tension of the area supporting the weight." Beginning thus with a false premise, naturally he ends with false conclusions. It is scarcely hypercritical to say that for these fallacies to go unchallenged after receiving favorable editorial comments and being incorporated in a book, portends a tardy science of flotation.

In this discussion the underlying principles involved in calculating the flotability of solids and constructing profiles arising from surface tensions will be pointed out and the calculation of "theoretical capacities" left to the more ambitious.

Maximum Depression Against a Vertical Plate

Imagine a plate of unit horizontal length placed vertically with its lower edge below the surface of water with its faces so prepared that on one side $\theta = 90°$ and on the other, $\theta = 180°$. (θ is the angle of contact). It will appear in cross section at right angles to its length as shown in Fig. 1. Let h be the depth of the dimple in centimeters. It is obvious that the sum of the horizontal forces must be zero, otherwise there would be motion, and work would be done without the expenditure of energy, which is contrary to the laws of nature.[6]

Since, on one side, the surface of the dimple meets the plate at 180°, the horizontal component of the pull due to surface tension is zero. On the other side, it is 0.0715 gram (the assumed tensile strength of the film). Opposite and equal to this force is that of the head of the water from a to b, which is

$$h \times \frac{h}{2} = \frac{h^2}{2}; \quad \frac{h^2}{2} = 0.0715$$

$h_1 = 0.143$.

$h = 0.378$ centimeter, the maximum depth possible in pure water where the face is vertical.

Maximum Rise Against a Vertical Plate

The profile of the liquid surface wetting the glass, Fig. 2, is the inverted profile of the one where $\theta = 180°$ in Fig. 1, because hydrostatic pressure is the only variable, and it varies directly with depth—from the top of the meniscus in Fig. 2 to the bottom of the dimple in Fig. 1. The maximum rise is therefore 0.378 centimeter. The radius of curvature at any point is determined by the formula

$$P = \frac{T}{R}$$

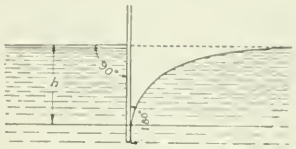


Fig. 1
Vertical plate with faces prepared so that θ is 90° and 180°

Note that in Fig. 1, where h was found to be 0.378 centimeter, the solid face was vertical. The maximum depth is obtained when the non-wetted face is horizontal. Let this depth be H.

Profile of a Drop of Water

If the liquid is resting on a solid which it meets at an angle of 180°, the drop will appear as shown in Fig. 3. The total hydrostatic pressure against an imaginary vertical plane of unit horizontal length against the right end is $\frac{H^2}{2}$. The opposite and equal force is 2 T, where T is the tensile strength measured in gram-weight per unit-length of film.

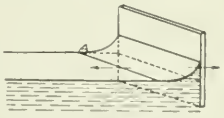


Fig. 2
Capillary rise against a vertical plate

$$\therefore \frac{H^2}{2} = 2T, \; H^2 = 4T = 0.286$$

$$H = 0.535 \text{ centimeter.}$$

To draw this, take a horizontal line to represent the upper plane surface. Having the value of H, take another line to represent the surface of the solid on which it rests. Let the surface of the water meet the solid surface at A. The radius of curvature R of the surface of the water where it leaves this solid is found by substituting the values for T and H in the formula for radius of curvature as given above.

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[1]Published in the *Journ. Phys. Chem.*, April, 1918, by permission of the Director of the U. S. Bureau of Mines.

[2]Metallurgist, U. S. Bureau of Mines, Seattle, Wash.

[3]"Fellow," College of Mines, University of Washington.

[4]T. J. Hoover: "Concentration of Ores by Flotation," p. 77 (1914).

[5]G. D. Van Arsdale: "How Flotation Works," Eng. & Min. Jour., 101, 851 (1916).

[6]The equilibrium of this system and the one in Fig. 2 was discussed by Le Conte and Riley in the Philosophical Magazine in 1883. Le Conte fell into a dispute with Young who "insisted that according to Laplace's theory the horizontal molecular pressures on the opposite faces being unequal, the composite plate should be drawn in the direction of the center of concavity of the meniscus on the glass face (Fig. 2), and thus cause the entire system to take on a motion of translation.

He, therefore, "made the following arrangements with the view of experimentally testing the question. A plate of well cleaned glass and a plate of polished steel were cemented together so as to constitute a composite plate of these substances. This was floated in a vertical position by securing masses of cork to the two faces, and attaching a leaden sinker of the proper weight to the lower extremity of the plate. If such a composite plate is plunged vertically into alcohol contained in a large vessel, a concave meniscus will be formed by the ascending liquid on the glass face, while on the steel face no meniscus will be formed, and the adjacent surface of the alcohol will be horizontal. There was no evidence of unbalanced forces on the floating face."

Riley investigated these principles and in liquid condition represented by Fig. 1 and found that in "every case the identity shewn that the magnitude of these two forces is just the same as if the surfaces came up perfectly level to the plate without any elevation or depression."

$$P = \frac{T}{R} = H$$

$$0.535 = \frac{0.0715}{R}$$

$$R = 0.134 \text{ centimeter.}$$

From "A" measure a distance R vertically upward, and with the point so chosen, describe a small circular arc radius R, to represent the lowest arc of the profile. The remaining arcs of the profile are drawn as indicated by the figure.

It is not absolutely correct mathematically to apply the formula

$$P = \frac{T}{R}$$

in this case. It is correct only when a surface element is obtained by bending a flat surface about a straight

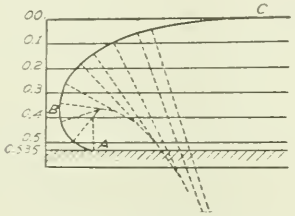

Fig. 3
The arc method of constructing the profile of drops of water

line as an axis, *i. e.*, only one plane of bending, giving a cylinder. With the flattened drop there are really two planes of bending at right angles to each other, and when the radii are R_1 and R_2, the correct formula is

$$P = T\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

Generally, however, R_2 is so large that $\frac{1}{R_2}$ may be neglected. When $R_1 = R_2$, we have, of course, the spherical drop.

The Proverbial Steel Needle

The following demonstration of equilibrium of the floating needle is taken from Edser:[2]

Let Fig. 4 represent the transverse section of a needle of radius r, floating on water. Let the surface of the water leave the needle tangentially at B, where the radius CB of the needle makes an angle A with the vertical. Let the point D be at a distance, h, below the flat surface of the water.

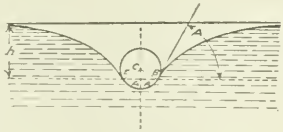

Fig. 4
Transverse section of wire floating on water when θ is 180°

The following are the upwardly directed forces acting on unit length:

The force due to the surface tension of the water is equal to

$$2\ T \sin A \qquad (a)$$

If the portion of the needle below the horizontal plane EB were removed, the hydrostatic pressure of the water would exert an upward force equal to

$$2\ r \sin A\ h \qquad (b)$$

The additional upward force due to the segmental portion of the needle below EB is equal to the weight of the water displaced by this portion of the needle; that is,

$$r^2\left(\pi \cdot \frac{A}{180} - \sin A \cos A\right) \qquad (c)$$

It is assumed that the length of the wire in comparison with the diameter is so great that the surface-tension pull upon the ends may be neglected.

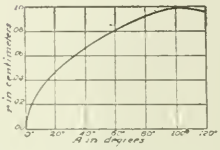

Fig. 5
Graph exhibiting relation of r and A for steel wire on water where θ is 180°

The downward force is

$$7.7 \cdot \pi\ r^2 \qquad (d)$$

We now wish to eliminate h in Equation b. Inspection shows that for horizontal forces in FB to be in equilibrium,

$$\frac{h^2}{2} = T - T \cos A$$

$$h = 2\sqrt{T}\sqrt{\frac{1 - \cos A}{2}}$$

$$= 2\sqrt{T} \sin \frac{A}{2} \qquad (e)$$

Substituting this value for h in equation b and equating the upward and downward forces, we obtain the equation

$$2T \sin A + 4r \sin A \sin \frac{A}{2} \cdot \sqrt{T} - r^2\left(\pi \cdot \frac{A}{180} - \sin A \cos A\right) = \pi r^2 7.7$$

Setting sin A cos A equal to 0.5 sin 2A $\qquad (f)$

and transforming,

$$r^2\left(24.2 - 0.5 \sin 2A - \pi \cdot \frac{A}{180}\right) - 1.07r \sin A \sin \frac{A}{2} = 0.143 \sin A \qquad (g)$$

Fig. 5 shows the values of r for values of A lying between 0° and 120°. It will be noted that the maximum value of r corresponds to A = 100°, and is equal to 0.0995 centimeter, or roughly 1 mm. Thus the diameter of the largest needle that can float on water is equal to two millimeters approximately. The position of the needle relative to the surface is shown in Fig. 6. The curve in Fig. 5 shows that the needle is in unstable equilibrium when A is greater than 100°.

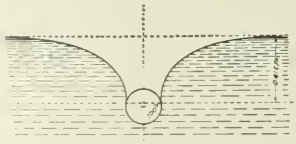

Fig. 6
Steel wire floating on water where θ is 180° and r is a maximum

Liquid Profiles.

A method of constructing liquid profiles is shown in Fig. 3. Its inaccuracy becomes apparent when one attempts to apply it; there is a cumulative error which necessitates "fudging" the curve to make it become tangent at "C." An exact method is desirable.

[2] Edwin Edser: "General Physics for Students," p. 340 (1911).

A search of the scientific literature reveals the fact that some of the scientists have been unable to deal with this curve in a scientific manner, using instead "cut and try" methods. A striking example of this is found in the paper of Richards and Coombs,[8] where they made elaborate experiments to "discover" the "diameter necessary in order to attain the flat surface with which the capillary rise is to be compared" while measuring surface tension by the capillary rise method. After investigating the literature and making many tests, they decided that "in the 38 mm. tube, a portion in the middle, apparently about 5 mm. in length, appeared to be flat, coinciding exactly with the horizontal spider-line of the telescope." From this it appears that in a a large glass receptacle where θ is zero, or nearly so, the meniscus would coincide with the plane surface of the liquid at a distance 16.5 millimeters $\left(\frac{38 - 5}{2}\right)$ from the wall. Since the upper portion of the profile (that above B) in Fig. 3 is like the inverted profile of the meniscus referred to, it would be expected therefore that the horizontal distance from B to C would be 1.65 centimeters. The error in the conclusions of Richards and Coombs is indicated below.

Construction of Profile Based on a Co-ordinate System

A comparison of the theoretical and observed positions of floating cylinders where the specific gravity, angle of contact and surface tension are known would add to the significance of these factors when applied to the study of floating minerals. To do this a correct liquid profile must be constructed by means of co-ordinates. Gray's[9] work aids in this regard. Under the subject of capillarity he gives the equation of this curve but treats it so academically that one finds it difficult to make the technical application. His equation is

$$x = -(4a^2 - y^2)^{\frac{1}{2}} + a \log \frac{2a - (4a^2 - y^2)^{\frac{1}{2}}}{y} + C$$

It is interesting to note at this point that Lord Kelvin

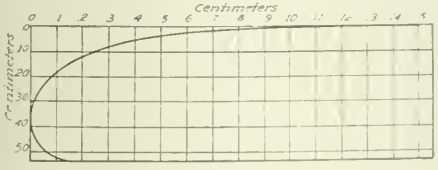

Fig. 7
Profile of standing water with one plane of bending
T = 0.0715 gram

and Tait[10] have likewise applied this equation to the curve of a bent wire. Hall[11] has also used it. If we set $2a = 0.535$ (the value of H), $C = 0.1427$ and change the Napierian logarithm to the common system by multiplying by 2.3, it takes the form

$$x = -(0.2862 - y^2)^{\frac{1}{2}} + 0.6152 \log \frac{0.535 - (0.2862 - y^2)^{\frac{1}{2}}}{y} - 0.1427$$

Table I gives the x, y ordinates.

The remarkable coincidence of this curve (Fig. 7), with the portion of Fig. 3 in which the arc method of construction has the minimum error, and the deviation from it where the error is obviously maximum, dispels all doubt toward the application of the formula to the profile of a standing liquid with one plane of bending."

TABLE I. CO-ORDINATES FOR LIQUID PROFILE WHERE THERE IS ONLY ONE PLANE OF BENDING.

T = 0.0715 g. sp. gr. = 1

x	y	x	y
0.143	0.535	0.1828	0.13
0.0809	0.52	0.2032	0.12
0.0645	0.51	0.2240	0.11
0.0517	0.50	0.2479	0.10
0.0332	0.48	0.2749	0.09
0.0149	0.45	0.3052	0.08
0.0050	0.42	0.3409	0.07
0.0011	0.40	0.3799	0.06
0.0000	0.378	0.4278	0.05
0.0018	0.35	0.4768	0.04
0.0085	0.32	0.6714	0.02
0.0154	0.30	0.8663	0.01
0.0244	0.28	0.9331	0.0075
0.0421	0.25	1.0015	0.0050
0.0580	0.23	1.2266	0.0025
0.0746	0.21	1.3630	0.0015
0.0843	0.20	1.4710	0.0010
0.1199	0.17	1.5480	0.00075
0.1496	0.15	2.0866	0.00010
0.1671	0.14		

Reference to the last two values of y and x in Table I shows that the 1.65 centimeters, taken by Richards and Coombs as the distance from the solid at which the meniscus coincides with a plane surface, allows an error of less than 0.00075 centimeter and more than 0.00010 centimeter. This appears in Fig. 7 and Table I.

Having this curve, we can now consider the angle of contact.

The Practical Formula for Steel Wires Floating on Water.

In the formula developed for the floating "needle," θ was taken as 180°. Since this value is likely never found in practice, it must be regarded as ideal. By a simple substitution a variable which will make it applicable for all values of θ is introduced, after which theoretical and observed values may be compared.

The corrections are simple, though at first somewhat confusing.

Since, in practice, the angle of contact is always less than 180°, an angle D is introduced to represent this difference. Equation *a* then becomes,

$$2T \sin (A - D) \qquad (a')$$

Equation *e* becomes

$$2L = T \sin \frac{A - D}{2}$$

and when this value is substituted in (*b*) we have

$$4rL = T \sin A \sin \left(\frac{A - D}{2}\right) \qquad (b')$$

The expressions (*c*) and (*d*) are unchanged.

Equation *g*, which applies to steel wires, then becomes

$$r\left(21.2 - 0.5 \sin 2A \frac{A}{180}\right) = 1.07 \sin A \sin \left(\frac{A - D}{2}\right) - 0.143 \sin (A - D) \qquad (g')$$

Table II gives the values of A and D for stated values of θ.

Fig. 8 shows the curves conforming to the co-ordinates given in Table II.

[8] T. W. Richards and L. B. Coombs, "The Surface Tension of Water and the Alcohols," Jour. Am. Chem. Soc., [illegible]

[9] A. Gray, "A Treatise on Physics," 1 [illegible]

[10] Lord Kelvin and P. Tait, "Treatise on Natural [illegible] Part 2, p. 149.

[11] T. P. Hall, Phil. Mag., 36, 285 (18[illegible])

[illegible]

TABLE II. VALUES OF A AND r IN EQUATION g'. STEEL WIRES

θ = 180° D = 0°		θ = 168° D = 12°		θ = 150° D = 30°		θ = 135° D = 45°		θ = 105° D = 75°		θ = 90° D = 90°		θ = 75° D = 105°		θ = 45° D = 135°	
A	r cm	A	r	A	r	A	r	A	r	A	r	A	r	A	r
0	0.0000														
10	0.0320														
		12	0.0000												
20	0.0461	20	0.0291												
30	0.0572	30	0.0444	30	0.0000										
40	0.0667	40	0.0563	40	0.0333										
						45	0.0000								
50	0.0752	50	0.0660	50	0.0482	50	0.0234								
60	0.0829	60	0.0753	60	0.0602	60	0.0421								
70	0.0895	70	0.0829	70	0.0704	70	0.0553								
								75	0						
80	0.0941	80	0.0896	80	0.0792	80	0.0668	80	0.0242						
90	0.0976	90	0.0946	90	0.0864	90	0.0765	90	0.0455	90	0.0000				
100	0.0994	100	0.0979	100	0.0921	100	0.0839	100	0.0573	100	0.0345				
												105	0.0000		
110	0.0987	110	0.0989	110	0.0957	110	0.0897	110	0.0682	110	0.0510	110	0.0247		
120	0.0961	120	0.0981	120	0.0974	120	0.0936	120	0.0767	120	0.0630	120	0.0446		
130	0.0906	130	0.0946	130	0.0967	130	0.0947	130	0.0830	130	0.0721	130	0.0572		
140	0.0824	140	0.0885	140	0.0946	140	0.0943	140	0.0869	140	0.0784	140	0.0669	140	0.0248
150	0.0714	150	0.0798	150	0.0880	150	0.0912	150	0.0886	150	0.0828	150	0.0739	150	0.0433
160	0.0570	160	0.0686	160	0.0801	160	0.0857	160	0.0879	160	0.0848	160	0.0784	160	0.0554
170	0.0388	170	0.0547	170	0.0701	170	0.0783	170	0.0853	170	0.0863	170	0.0803	170	0.0635
180	0.0000	180	0.0380	180	0.0580	180	0.0690	180	0.0807	180	0.0821	180	0.0807	180	0.0690

The Relation of Angle of Contact to Flotability.

We now have sufficient data to show the relation of the angle of contact to the flotability of cylinders. The

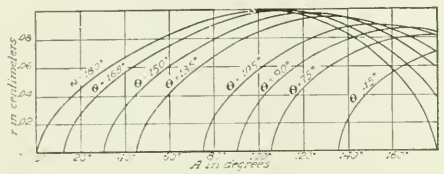

Fig. 8

Curves showing the theoretical values of A for steel wires for stated values of r and θ

subject begins to take the aspect of a science when we see from this figure that if r is sufficiently small a solid is flotable though θ may be as small, for example, as 45° or less. Previously, the fact that pieces of glass floated on water could be explained only by the "air cushion" theory. Such an hypothesis must now give way to facts. Consider, for example, a steel wire with a radius of 0.06 centimeter. Reference to Fig. 8 shows that when $\theta = 180°$, $A = 33°$; $\theta = 168°$, $A = 44°$; $\theta = 150°$, $A = 60°$; $\theta = 135°$, $A = 74°$; $\theta = 105°$, $A = 102°$; $\theta = 90°$, $A = 117°$; $\theta = 75°$, $A = 133°$; $\theta = 45°$, $A = 165°$. The very slight drop in the consecutive crests of the curves from left to right, while θ decreases from 180° to

Fig. 9

Showing how a steel wire of given diameter ($r = 0.06$ cm) rides on pure water while θ decreases from left to right

45°, is striking. But this must not be taken to indicate relative flotability in practice. For, though it is true that increasing "A" brings the object near the point of unstable equilibrium (the descending portion of the curve), yet another factor of no less importance appears in practice. It is the position of the walls of water with reference to the object, and to each other. Note in Fig. 9, *a*, how the object rides safely on a disturbed surface, while in Fig. 9, *h*, there is continual danger of the walls overlapping and causing submergence. When they overlap and coalesce, the surface tension film, of course, vanishes. A little lycopodium powder or talc on the surface assists in maintaining the interface by preventing coalescence. Is it not probable that the insoluble oil used in flotation acts in the same manner, preventing the coalescence of the walls of the bubble whenever it is in danger of being separated from the mineral?

These theoretical considerations would have greater significance if supported by physical measurements and observations. Such tests have been made with the cathetometer, and the agreement of observed and calculated values justifies the theory. Let us first consider the principles involved in constructing Fig. 9, after which we shall consider the physical measurements.

Take, for example, Fig. 9, *b*. The radius of the steel wire is 0.06 centimeter and θ is 168°. The angle D is therefore 12°. Look along the line (Fig. 8), corresponding to $r = 0.06$ cm. and find where it intersects the curve marked "$\theta = 168$." Here the corresponding angle A is 44°. Now use the modified form of Equation *e*, which is,

$$h = 2r \sin \frac{A - D}{2}$$

This gives the value of h, which is then applied to Fig. 9. At the point on the curve so determined strike off the radius of the object so that "A" has the value desired, and draw the circle.

Of course, θ must be determined by test. The classic methods for this determination were considered, but discarded in favor of an indirect method in which the cathetometer was used. Here the capillary rise or depression against a vertical plane surface was determined, and θ was found by means of the above equation by solving for D after setting A equal to 90°. When there is capillary rise, θ equals D, and for capillary depression θ equals 180° minus D. Pure water gives an angle of contact of 168° against a surface prepared by dipping a solid into molten paraffin and sprinkling lycopodium powder on it before the paraffin congeals. Against solid paraffin the angle is 105°.

Table III shows that the observed and theoretical position of steel wires floating on pure water coincide with a satisfactory degree of accuracy. The cathetometer was used to measure the vertical distance from the plane surface of the water to the bottom of the floating wire. No correction was made for the thickness of the paraffin shell, which was found to be very thin—only 0.01 centimeter. Fig. 10 shows the theoretical position of these wires on the liquid profile. The liquid

meets the heavy and dotted circles at 168° and 105°, respectively.

TABLE III.—SHOWING THE OBSERVED AND THEORETICAL DEPTH OF STEEL WIRES FLOATING ON PURE WATER

Radii of Wires in Centimeters	$\theta = 168°$ Depth in Centimeters		$\theta = 105°$ Depth in Centimeters	
	Observed	Theoretical	Observed	Theoretical
0.0440	0.090	0.082	0.120	0.115
0.0520	0.125	0.129	0.160	0.156
0.0684	0.205	0.212	0.260	0.253
0.0855	0.330	0.335	...	

The Flotation of Aluminium Wires

From the standpoint of the metallurgist, we are still dealing with an ideal case because minerals cannot be obtained in the form of right circular cylinders; again,

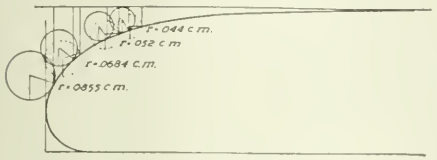

Fig. 10
Theoretical positions of steel wires floating on water where T is 0.0175 and θ is 105° and 168°, respectively.

steel wires have a greater specific gravity than many of the metallic sulphides. In order to transform ideal conditions into the practical, let us make a further study of the effect of specific gravity, reserving the question of shape of the floating object for a later discussion.

Having made a study of the conduct of wires heavier than the average of the metallic sulphides, it seems that if we would make a similar study of those lighter than the minerals and find an agreement also between theoretical and observed values, we could use mathematical processes for predicting the conduct of any mineral. The following results deal, therefore, with aluminium wires:

When aluminium wires (specific gravity 2.7) are used, the equation corresponding to Equation g' is

$$r^2\left(8.4823 \cdot 0.5 \sin 2A - \frac{A}{180}\right) = 1.07r \sin A \sin\left(\frac{A - D}{2}\right)$$

$$= 0.143 \sin (A - D)$$

The values of A and r for stated values of θ are shown in Table IV.

TABLE IV. VALUES OF r AND A ALUMINIUM WIRES

$\theta = 168°$ D = 12°		$\theta = 105°$ D = 75		$\theta = 90°$ D = 60	
A	r	A	r	A	r
12	0.0000				
20	0.0499				
30	0.0775				
40	0.1004				
50	0.1216				
60	0.1422				
70	0.1626				
		75	0.0000		
80	0.1812	80	0.0446		
90	0.1986	90	0.0833	90	0.0000
100	0.2129	100	0.1145	100	0.0686
110	0.2210	110	0.1413	110	0.1033
120	0.2262	120	0.1630	120	0.1312
130	0.2217	130	0.1795	130	0.1531
140	0.2083	140	0.1832	140	0.1686
150	0.1860	150	0.1931	150	0.1771
160	0.1564	160	0.1870	160	0.1769
170	0.1182	170	0.1761	170	0.1733
180	0.0744	180	0.1602	180	0.1631

These points are plotted in Fig. 11. The scale is the same as that of Fig. 8. Note how they have the same general form as those for steel, but run up much higher on account of the lesser density of the aluminium. The remarkable coincidence of the theoretical depth with the observed depth of the bottom of the wire below the plane surface of the liquid again substantiates the theory. See Table V.

TABLE V.—SHOWING THE OBSERVED AND THEORETICAL DEPTH OF ALUMINIUM WIRES FLOATING ON PURE WATER

Radii of Wire in Centimeters	$\theta = 168°$ Depth in Centimeters		$\theta = 105°$ Depth in Centimeters	
	Observed	Theoretical	Observed	Theoretical
0.065	0.067	0.065	0.102	0.100
0.095	0.136	0.140	0.190	0.195
0.192	0.494	0.500		
0.215	0.680	0.642		

Fig. 12 shows the theoretical position of these aluminium wires on the liquid profile. The liquid meets the

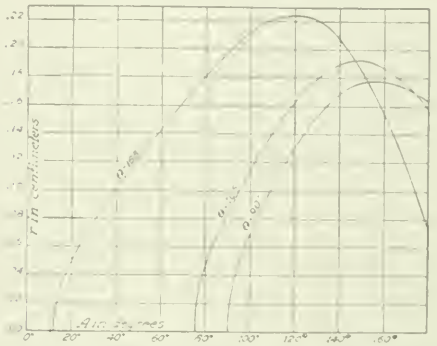

Fig. 11
Curves showing the theoretical values of A for aluminium wires for stated values of r and θ.

heavy and dotted circles at 168° and 105°, respectively, as in Fig. 10, where the steel wires were shown.

Anderson[1] says: "A needle, especially if slightly oily, will float if carefully placed upon water. We may note in passing that the weight of the water displaced by the sagging of the surface film is equal to the weight of the needle (Archimedes' Principle)." This statement will be discussed in another paper.

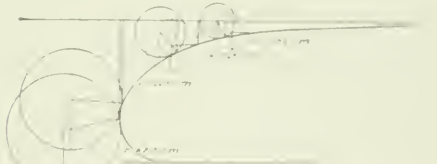

Fig. 12
Theoretical [illegible] floating [illegible]

The Flotation of Galena

To compare the conduct of the mineral grains fed to a H. F. Wood flotation machine to a group of skaters where some glide over the ice and others break through, is an analogy that is fruitless. Ice breaks when the molecules are removed beyond the limit of influence, but at the instant when galena [illegible] the molecules in the surface of the liquid are under the same stress as those on an undisturbed surface. To speak of the membrane rupturing or breaking at the instant the galena becomes submerged, is [illegible] far from accuracy as is the

[illegible]

North from the South. We must have the facts or continue the guessing process in flotation, which, it must be admitted, has, in some cases at least, produced such favorable results that a "small piece of cheese has been left for the cats after the monkey got his portion."

What is the position of floating galena relative to the liquid profile? The angle of contact of pure water against cleavage face is approximately 45°. Is a mineral flotable when the water turns up at this angle to meet a vertical face? Figs. 8 and 9 show that wires are, and it seems consistent to assume that the same conclusion applies to minerals. Conjecture offers only one explanation—diagrammed in Fig. 13. Cathetometer observations show that this is a reality. The liquid profile meets the upper horizontal face (at 45°), the proof of which is shown in Table VI.

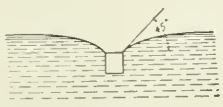

Fig. 13
Diagram showing how galena floats on water when θ is 45°

TABLE VI CATHETOMETER OBSERVATIONS ON FLOATING GALENA

Approximate Mesh	Vertical Dimensions in Centimeters: Of Galena	Bottom of Galena to Intersection of Liquid Profile With Galena
36-mesh	0 040	0 055
33-mesh	0 045	0 055
13-mesh	0 130	0 150
12-mesh	0 140	0 150

In each observation the readings showed that the mineral was wholly below the bottom of the dimple.

Summary

The maximum rise and depression of a given liquid against vertical plates are determined and shown to be the same for angles of contact of 0° and 180°, respectively. The horizontal pull of the film is independent of the angle of contact.

A graphical method of constructing a liquid profile with one plane of bending is reviewed.

A review is given of the mathematical discussion of the floating needle when the angle of contact is ideal.

A liquid profile with one plane of bending is constructed on a co-ordinate system, and compared with the arc and "cut and try" methods.

A practical formula for steel wires floating on water is developed from the ideal and theoretical and observed values are compared.

A formula is developed for calculating angle of contact from the cathetometer measurements of rise or depression of a liquid against a vertical plate. The relation of angle of contact to flotability is indicated by curves and checked by observations.

The flotation of aluminium wires is treated scientifically and practically.

The manner in which "floating" galena is suspended at the surface of water is shown.

Brazil Subsidizes Caustic Soda.—Owing to the impossibility of obtaining supplies, the Brazilian Government has just published a decree offering financial assistance to establish caustic-soda factories, loaning up to 75 per cent of cost of construction, the amounts not to exceed $500,000 for each of the first three factories with minimum production of 500 tons per year.

Research Fellowships in Metallurgy School of Mines, University of Idaho

In co-operation with the United States Bureau of Mines, the University of Idaho, through the generosity of the mine owners of the state, offers in the School of Mines a number of fellowships in metallurgy. These fellowships are open to college graduates who have had good training in chemistry and metallurgy, and who are qualified to undertake research work. The income of each fellowship is $720 a year of twelve months beginning July 1st, 1918.

Fellows will register as students in the University of Idaho and become candidates for the degree of Master of Science in Mining or Metallurgy (unless this or an equivalent degree has been earned.) Their class work will be directed by the heads of the departments of instruction, but the greater portion of their time will be spent in research work under the direction of the Bureau of Mines staff resident at the University. The purpose of this work is to undertake the solution of definite problems confronting the mining and metallurgical industries of the state of Idaho. For 1918-19 the following subjects are to be investigated:

(1) Differential flotation—with especial reference to the zinc-lead ores of the Coeur d'Alene.

(2) Availability of western wood-oils for flotation concentration.

(3) Treatment of the complex gold-silver ores of southern Idaho.

Under the ruling of the War Department candidates 21 years of age or over who are accepted for the fellowship, will be allowed to enlist in the Engineers Reserve Corps detailed to continued their studies, and placed in a deferred classification for the period of their enrollment as graduate students.

Applications, with certified copy of collegiate record, and names and address of three references will be received up to June 1st, 1918. The applications should be addressed to The Dean, School of Mines, Moscow, Idaho.

Kaiser Wilhelm Trust for Promotion of the Science of War

The Kaiser has approved the foundation of a Trust with the name given above. The aim of the Trust is to further the development of scientific and technical aids to warfare, by uniting the scientific and the military forces of the country for work together. The scientific work is to be carried on by the following technical committees (or commissions):

(1) Committee for the chemical raw materials, for the production of munitions-manufacturing materials.

(2) Committee for chemical war materials (powder, explosives, gas, and the like).

(3) Committee for physics, including balistics, telephony, telegraphy, determination of targets and distances, measurements, and the like.

(4) Committee for engineering and communication.

(5) Committee for aeronautics.

(6) Committee for obtaining and preparation of metals.

The Economic Position of Oil Shales

Economic Distribution, Methods of Production and Comparative Yields

BY JAC C. MORRELL AND GUSTAV EGLOFF

THE increasing need of petroleum oil is steadily outdistancing the visible supply to such an extent that the oil shales of the West are already being considered not only to make up a developing shortage, but as the future oil reserve. Various statistics show that since 1913 the consumption of petroleum crude oil has grown faster than production at the wells in the United States. The Government has classified 3,692,036 acres as oil-shale land in the West. During the last year two oil-shale reserves were created for the use of the navy, one of 45,440 acres in Colorado, and one of 86,584 acres in Utah.

Statistical Situation

In Senate document 310 it is indicated that the maximum amount of oil in the known oilfields would yield 7,629,000,000 barrels. From 1859 to Jan. 1, 1918, the total number of barrels of crude petroleum oil produced in the United States was 4,200,000,000. From a production of 2000 barrels in 1859 the number increased to 286,000,000 in 1917. M. L. Requa has stated that by assuming the annual increase as 5 per cent of the previous year's production, there would be required in 1925 409,000,000 barrels of crude oil. In 1917 the production of crude oil was 286,000,000 barrels, and, according to the Geological Survey, there is only 7,629,000,000 barrels of extractable petroleum oil in the known fields of the United States. Thus there is only a known oil supply available for twenty-three years. This calculation is on the assumption that there is no yearly increased demand for petroleum products. But on the basis of past yearly increase in petroleum consumption the estimated available supply will last probably fifteen years.

KEY MAP OF NORTHWESTERN [illegible] AND ADJACENT AREAS

Assuming that new oilfield deposits and known production may be tripled, our oil supply will last a scant fifty years. It is well known that a number of our oil areas are decreasing yearly in production, and although the total barrels of crude oil production increases yearly, the amount is not great enough to supply the demand for refined products. Hence, the necessity of taking crude oil from storage. On Jan. 1, 1916, 198,000,000 barrels of crude oil and on Jan. 1, 1918, approximately 155,000,000 barrels were in storage, which shows a depreciation of 43,000,000 barrels, leaving less than a six months' supply of crude oil above ground for refining. In 1917 there were 359 refineries in operation, with a yearly capacity of 450,000,000 barrels of crude oil.[1] At the present time there are 118 new refineries building, with a yearly capacity of 40,000,000 barrels. In the year 1918 there will be operating 477 refineries, with a yearly capacity of 490,000,000 barrels.

The United States production of petroleum crude in 1918 will be 300,000,000 barrels. The addition of 50,000,000 barrels from Mexico will give a total of 350,000,000 barrels, but this quantity will not keep the refineries at capacity operation, unless several Cushing, Towanda and Eldorado pools are brought in or the difference be piped from Mexico's prolific field to meet the increasing demand for refined petroleum products. Although the petroleum crude oil of the United States may be exhausted in fifty years, one must not forget the vast deposits in Mexico. For the year 1916 Mexico shipped 40,000,000 and in 1917 50,000,000 barrels of crude oil to the United States. At the present time Mexico has a potential of at least 500,000,000 barrels' production a year, which could be moved to the United States if adequate transportation were available. And, furthermore, the resources of the oil deposits of South America have not been tapped as yet for use in the United States.

Importance of Oil Shales

In view of the above facts, the subject of oil shales has become important, and much is being written about it. Most of the literature, however, deals with statistics concerning the oil shales of a particular locality, and very few attempts have been made to co-ordinate the subject as a whole.

Almost all solids capable of giving up oil either by heat treatment, or by the use of solvents, have been

[1] W. C. Teagle, *Oil and Gas J.*, 11 (1913)

classified as oil shales, and although the writers make no pretense that a strict classification can be made, yet a treatment of the most important types of solids producing oil referred to as oil shales may help to clear the field a little.

The relations of these various types to one another, their possible mode of origin, their relation to other solid hydrocarbons and to petroleum, with a discussion of the economic distribution and treatment of oil shales, and the uses of their products, have been correlated by the writers.

Clays, Shales and Slates

The name clay is applied to argillaceous or sedimentary deposits still retaining enough moisture to be plastic. By loss of this uncombined water these clays pass into mudstones, shales and slates. When these fine-grained rocks are composed of sand or limestone sediments they are termed argillaceous sandstones or limestones. A shale is supposed to be a consolidated mud or clay in which the principal constituents are silicates of alumina. As soon as the consolidated clay begins to develop bedding planes and shows a tendency to split along the original laminæ the rock is termed a shale. Further, pressure, sometimes assisted by igneous intrustion, causes a partial change in mineralization, and the original bedding planes are superseded by a new direction of weak cohesion called slaty cleavage, and the resulting rock is called a slate. Pressure alone causes the colloidal particles in muds and clay to cohere, cementation seeming to be a minor factor. The extent to which muds and clays are converted into shales is therefore a function of the pressure. These clays and shales have the property of absorbing petroleum to a limited extent. The adsorptive property of clays and shales for oil has been shown to depend in part on colloid content, which in turn changes with chemical composition.

For comparative purposes Table I tabulates the inorganic content of clays, limestones, shales and similar substances. Some of the spent shales are relatively high in alumina content and may have economic value on that ground, but their importance will lie in the working out of satisfactory cements, clays for pottery, brick and paving material for streets by blending with suitable binders.

Origin of Petroleum

The theories as to the origin of petroleum can be divided into two great classes, namely, the inorganic and organic. The main support of the inorganic theory lies in the fact that hydrocarbons of the acetylene, ethylene and methane series can be produced by the hydrolysis of metallic carbides. The carbide theory has few adherents at the present time. The organic theory is divided into three classes, namely, animal, vegetable, and a combination of the animal and vegetable theories. Under the heading of animal origin of petroleum is the theory that the existence of petroleum is due to the decomposition of marine animals, such as fish, oysters, scallops and a microscopic organism called foraminifera, the latter being found in great quantities along sea coasts in beds hundreds of feet thick. The vegetable theory includes the formation of petroleum from seaweed, land plants and diatoms. The enormous quantity of kelp found along sea coasts lends support to the seaweed theory. It has been clearly shown by numerous investigators that coal is formed from land plants. It is possible that under different conditions petroleum would be formed from plants or that possibly oil was distilled from coal in nature, as may readily be done in the laboratory. It can readily be seen that all possible combinations of the animal and vegetable theory are possible, especially since the remains of animal and vegetable matter are found in the same strata.

Table I—Analysis of Clays, Limestones, Shales and Cannel Coal

Type	Per Cent				
	Silica	Alumina	Iron Oxide	Calcium Oxide	Magnesium Oxide
Fire clay (a)	73.82	15.88	2.95	Trace	Trace
Brick clay (a)	49.44	34.26	7.74	1.48	5.14
Average 106 American clays (a)	52.60	21.00	14.80	3.58	2.98
English, Fuller's earth (a)	53.00	10.00	9.75	0.50	1.25
California, Fuller's earth (a)	54.32	18.18	6.50	1.00	3.22
New Brunswick, Can., clay (b)	75.40	11.40	3.50	0.86	1.17
New Brunswick, Can., gypsum (b)	0.30	0.05	0.05	32.30	0.10
New Brunswick, Can., oil shale (b)	30.3	11.50	4.50	6.00	3.50
New Brunswick, Can., spent oil shale (b)	49.6	16.80	7.30	9.90	5.71
New Albany, Ind., black shale (c)	50.5	14.9	....	0.10	0.10
Norfolk English shale (d)	49.5	20.2	10.30	11.70	1.20
Broxburn spent shale (a)	49.72	18.8	16.80	2.40	2.20
Broxburn spent shale (a)	55.97	31.21	2.84	0.59	1.87
Torbanite spent shale (a)	56.70	36.20	3.20	1.30	0.40
Wurtzilite spent shale	36.90	20.57	8.86	11.90	5.30
Wainwright cannel coal (e)	46.20	32.86	13.14	0.49	1.22
Bunceton cannel coal (e)	50.40	19.70	18.90	1.29	1.73
Herrin cannel coal (e)	56.44	12.65	25.71	0.50	0.58

(a) Craig, Jour. Inst. Petr. Techn. 2, 265, 1916.
(b) Ells, Canada Dept. of Mines, Mines Branch 26, 24, 1911.
(c) Forbes-Leslie Jour. Inst. Petr. Techn. 3, 22, 1916.
(d) Ashley, U. S. Geol. Survey, Bull. 641 L, 323, 1917.
(e) Ingram, Bulletin School of Mines, University of Missouri, 3, 24, 1917.

The organic matter laid down in beds is prevented from too rapid oxidation by an impervious seal of water overhead, and the formation of oil may be caused by magmatic intrusion under heat and pressure by a process of distillation or diffusion through porous mineral matter.

Oil and gas deposits always occur in higher parts of folds in the earth's surface called anticlines, domes and monoclines. The rocks composing these folds are sedimentary or water laid deposits, such as sands, sandstones, limestones and shales. Water occurs in the same stratum as the oil, but in a lower part of the fold. The oil does not occur in pools, but is retained in reservoirs consisting of coarse sands, porous limestones, sandstones and shales. These deposits retain the oil in the spaces between the grains and are capped, as well as underlaid, by impervious beds, thus preventing the escape of the oil. Some of these caps have been broken and replaced by layers of asphaltic and paraffin deposits left by the evaporation of the more volatile constituents. Such caps give us a hint as to the possibility of the formation of bituminous shales where conditions were such that simultaneous slow evaporation and oxidation of an asphaltic base oil impregnating a shale would leave a product such as is represented by some of our oil shales. This process may have gone on before or after the clay was consolidated into a shale, or the consolidation may have assisted the process.

Some Solid Hydrocarbons

No discontinuity is shown in passing from natural gas through liquid petroleum to solid asphalt and bituminous coal. The physical properties are progressive

in going from gases through liquids and viscous mixtures to solids.[2] All of this suggests a common origin. The solid hydrocarbons found in nature are known generically as bitumens and asphalts. "Bitumen is described as a naturally occurring mixture of native or pyrogenous hydrocarbons and their non-metallic derivatives, which may be gases, liquids or solids soluble in carbon bisulphide and benzol."[3]

The asphalt of Pitch Lake, described by Richardson,[4] is an emulsion of water, gas, bitumen and mineral matter. The gas consists mainly of hydrogen sulphide and carbon dioxide. The analysis of purified Trinidad bitumen is as follows:

	Per Cent
Carbon	82.33
Hydrogen	10.69
Sulphur	6.16
Nitrogen	0.81

Investigation showed that the hardness of bitumen increased with the sulphur content and indicated that sulphur was probably active in hardening the bitumen. Among the most abundantly occurring solid hydrocarbon materials in the United States are gilsonite, tabbyite, wurtzilite, ozokerite and rock asphalt. These substances have varied uses in the industries. Gilsonite is used for paving, insulation, mineral rubber, roofing and water proofing. Tabbyite is used in making mineral rubber; ozokerite or mineral wax, which also occurs in Galicia, Austria, is used in making electrical insulators, and as a substitute for bee's wax. Rock asphalt, a sand conglomerate cemented by bitumen, is used for paving. Bardwell, Berryman, Brighton and Kuhre[5] have compiled some interesting data on the properties of these hydrocarbons. Some of these data are tabulated in Table II.

TABLE II

	Trinidad	Gilsonite	Tabbyite	Wurtzilite	Orokerite
Bitumen soluble in CS	60 36	99.64	94 63	10 83	99 46
Organic matter insoluble in CS	3 94	0.0	0.72	87 68	0 50
Inorganic or mineral matter	35.70	0.36	4 65	1 50	0 50
Loss on ignition	61 30	99.64	95 35	98 50	99 96
Fixed carbon	36.69	43.13	37 45	35 60	10.03
Sulphur	4 22	0 52	1 21	4 00	0 29
Total volatile at 400 deg. C	27.61	56 51	57 90	61.58	87 93

In all cases: streak colored brown, and fracture concholdal.

Wurtzilite was also found to be very little soluble in naphtha and carbon tetrachloride. It differed from the others by being insoluble in its own distillate and in the distillates of the others.

The case of wurtzilite, which resembles in composition the other hydrocarbons investigated, but differs from them in being practically insoluble in carbon bisulphide, etc., is not an isolated one. Cannel coal[6] and the Scottish shales are of the same nature, showing slight solubility in certain solvents.

In dealing with the origin of these solid hydrocarbons, experimental and geological evidence would tend to show that their source is practically the same as that of petroleum. Some of the best experimental evidence relating to the formation of these solid hydrocarbons is collected in *Bulletin* 616, issued by the United States Geological Survey, 1916. Some of these data, with original references, are given below.

Engler[7] distilled menhaden oil (fish oil) at temperatures varying from 320 deg. C. to 400 deg. C. and a pressure of 10 atmospheres. He obtained a distillate resembling petroleum, which upon being fractionated gave various type hydrocarbons.

C. W. Day[8] found that upon distilling fish (using fresh herring) a product formed which upon redistillation yielded a residue closely resembling gilsonite. With fish alone the final product was more like elaterite, a natural product closely resembling wurtzilite. Distillation of wood gave a similar residue. Thus natural asphalts were obtained resembling the natural substances and containing nitrogen similar to ordinary asphalt.

A specimen of albertite, an oil shale from New Brunswick, Canada, known as "paper shale," was examined by the writers and found to contain distinct fish remains. This shale was a highly indurated and laminated type, which seemed to be impregnated with bituminous material only along the bedding planes. Adjacent to this was a shale impregnated through and through with the bituminous material, and on whose surface was some pure bituminous material free from kaolinitic matter. The evidence in this particular bituminous substance may be a fish oil residuum.

Ells[9] in describing the oil shales of New Brunswick stated that they are often rich in fish remains. Many other writers cite the presence of fish remains in oil shales, which confirms the animal origin of both solid and liquid hydrocarbons.

This does not exclude the vegetable theory, since vegetable oils[10] likewise yield hydrocarbons upon destructive distillation, and the case of wood has been cited. The nature of liquid and solid hydrocarbons is thus seen to depend on the source, paraffin base oils being thought to be of vegetable origin and asphaltic base oils of animal origin.

OIL SHALES

It has been shown that shales, sandstones and limestones are of sedimentary origin. These rocks grade into one another and shales are found which contain considerable calcite and quartzite either in the original formation or by replacement. All of the rocks are capable of absorbing petroleum, and the resulting rocks are known as oil shales, oil sandstones and oil limestones. Shales which are simply impregnated with oil are not the type which are usually referred to in the literature as oil shales. They are, however, equally entitled to be called oil shales, and, as has been suggested previously, may really be the parent of the present day oil shale deposits.

Rocks referred to as oil shales vary greatly in character. In some types, such as paper shale, the bedding planes are prominent, while in others the laminæ are only developed upon retorting. In some cases the shales are not impregnated with the bituminous material, but the material seems to have simply forced its way along

[2] Maberry, Jour. Ind. Eng. Chem. 6, 101, 1914
[3] Bacon & Hamor, American Petroleum Industry
[4] Jour. Chem. Ind. 17, 13, 1898.
[5] Jour. Ind. Eng. Chem., Dec., 1913.
[6] Craig: Jour. Inst. Pet. Tech., June, 1916
[7] Engler Berichte 31, 1816, 1898
[8] W. C. Day, Amer. Chem. Journal, 21, 478, 1899
[9] Geol. Survey Report Dept. of Mines, Canada, 1909
[10] S. P. Sadtler, Proc. Am. Phil. Soc., 16, 93, 1877

the bedding planes. Gilsonite occurs in this manner, and albertite in some cases.

In a number of instances the oil and bituminous material contained in oil shales may be dissolved out by carbon bisulphide, benzol and similar solvents. The Scottish shales are, however, not of this character, and wurtzilite,[11] which has been found to be identical with the oil shales of the Green River formation in Western United States, has been shown to be only slightly soluble.

All of these types produce oil upon heat treatment, but[12] those which are insoluble have been classified as containing an oil producing substance which is neither bitumen, petroleum or resin. Crum Brown first employed the term kerogen to denote this substance. A kerogen shale is a shale containing kerogen as distinguished from one containing crude petroleum or bitumen.

Microscopic[13] examination of Autun boghead coals and New South Wales torbanite has shown the presence of irregular shaped yellow bodies, not disturbing the lamination, but sometimes extending across it. It was concluded that these bodies were introduced from some outside source, although Renault and Bertrand[14] looked upon them as being originally derived from a gelatinous algæ, and formed in situ.

Some of the "blaes" [15] (Scottish shales producing very little oil) are carboniferous, but on examination are found not to contain kerogen. In general it has been found that the amount of oil produced from this type of shale is proportional to the amount of these yellow bodies, called kerogen. Thus kerogen seems to be present in only the shales found in anticlinal regions. Examination of a section of this oil shale under the microscope brought out its fine grained and laminated character. The darker shales are more opaque than the lighter, and are consequently harder to examine. Varying quantities of vegetable debris are also present, the darker specimens usually containing more than light colored specimens.

Distribution and Mode of Occurrence

Oil shale occurs in economic deposits in the United States, Canada, Nova Scotia, Scotland, France, New South Wales, Australia, New Zealand, Tasmania, Spain, Austria Hungary, Turkey, South Africa, Brazil and Italy. The most important deposits are in the United States, Canada, Scotland and France.

The Scotch shales as described by Ells[16] are of a chocolate brown color and soft, being easily cut with a knife. They are free from gritty matter. They vary in oil content as well as in ammonium sulphate in different bands, and even in parts of the same bed. The shales approximate what is known as paper shales, and the beds vary in thickness from a few inches to 15 ft., being interstratified with blue-grey portions and hard calcareous or siliceous bands. In[17] area the shale beds cover an extreme length of about 24 miles.

Scotch shales used for oil are known by the terms "plain" and "curly." These are associated with a less rich portion known under the name of "blaes." The curly shale is the more valuable, a larger percentage of hydrocarbons making it softer and more crumbly and easier to mine. "Blaes" on weathering pass into muds. Rich shale, however, remains unchanged by exposure to weather conditions even for years.

The strata are often thrown into folds which bring different portions to the surface at various points. Most of the mining is underground, however, and some of the Scotch workings have been worked to a depth of 1000 ft., the mining being carried on after the fashion of mining bituminous coal. Roofs are supported with timber, props and pillars. A regular system of roads, driveways and drifts has been installed.

The oil shales of New Brunswick[18] are the most important of the Canadian oil shales. The Scotch shales are more papery than the New Brunswick shales, the shaly character of the latter being developed on retorting. The New Brunswick shales burn easily, only the large per cent of ash making it unfit for economic use at present. The types corresponding to the "curly," "plain" and "blaes" of Scotland are found in New Brunswick.

The oil shales of New Brunswick vary greatly in character, ranging from a thin bedded brownish or blackish grey, sometimes quite flexible and elastic, and usually known locally as paper shales, to massive bands of black, tough shales which occur as interstratified beds in the formation as a whole. While the greater part of these shales are bituminous the black massive beds which range in thickness from 3 to 7 ft. are much richer in ammonia, gas and crude oil than the great mass of thinner shales. The sands above these shales have been known to contain small quantities of oil, but as far as is known the oil shales do not contain any. The darker shales have an abundance of plant and fish remains.

The principal economic deposits of oil shale in the United States[19] lie in the Green River formation in Colo rado, Utah and Wyoming. There are deposits also in the Eastern[20] part of the United States, underlying the coal fields, cropping out in Alabama, Indiana, Pennsylvania, Tennessee, Virginia, Ohio, Kentucky and Illinois.

Winchester[21] has made an exhaustive examination of the Green River formation, and has made an extensive report on the Western oil shales. The Green River formation has a maximum thickness of 2,600 ft., the middle part of the formation containing the beds most rich in oil-producing shales. This formation consists principally of shale, but contains beds of sandstone, with oolite being present in some parts.

In Colorado the shale area includes probably twenty townships, being 50 miles long and 20 miles wide. In Utah the area may be even greater. As has been mentioned before, the government has reserved 3,692,036 acres of land in this area as oil land for the use of the navy.

These shales are for the most part insoluble in carbon bisulphide, benzol and similar solvents, and have been said to approximate wurtzilite in composition. The mineral matter in which the oil producing substance is held is a smooth non-siliceous clay containing a small amount of carbonate of lime.

[11] De Beque Eng. & Min. Jour., Dec. 9, 1916.
[12] Craig, Jour. Inst. Pet. Tech., June, 1916.
[13] Ibid.
[14] Compt. Rend. 117, 593, 1893.
[15] Craig, Loc. Cit.
[16] R. W. Ells, Canada, Dept. of Mines, 1908.
[17] De Beque, Eng. & Min. Journal, May, 1915.
[18] Report Dept. of Mines, Canada, 1909.
[19] Winchester Bulletin 641, U. S. Geol. Survey, 1916.
[20] Ashley, Bulletin 641, L., 1917.
[21] Bulletin 641, U. S. Geol. Survey.

In Colorado[23] it is estimated that the shale deposits are capable of yielding 20,000,000,000 barrels of crude oil, giving upon refining 2,000,000,000 barrels of gasoline, and those of Utah will probably produce an equal amount. The Colorado shale will probably also produce about 300,000,000 tons of ammonium sulphate, a substance useful as fertilizer and for the production of nitric acid for use in explosives. At many places in Colorado and Utah the rich shale has only a light overburden, and could be mined with a steam shovel, in this respect possessing a great advantage over the method of mining in Scotland and France. But there are particularly tough layers of shale which wear out steam-shovel teeth rapidly, even those of manganese steel, which will be an important factor in the cost of mining. However, in Scotland some pits and shafts are 1000 ft. deep, which factor is not present in the Colorado and Utah deposits.

The principal deposits of shale in France are in Autun and Buxieres. The former has been regularly exploited since 1862 and the latter since 1858. The oil shales in these two principal sections of France occur for the most part interstratified with calcite and quartz strata; the shale being approximately two meters in thickness. The Autun deposits cover about 18,000 hectares (36,000 acres), the mining of which is underground. The oil shale runs fairly uniform in the formation of oil and by-products.

Method of Production and Products

The distilling of oil shales has been known as early as 1694, when Eele, Hancock and Portlock made "oyle from a kind of stone" in England. The details of retorting practice in the various countries have been very well written up by the following experimenters. The French oil shale industry has been balanced against the practice in vogue in Scotland with statistics of production by Chosson,[24] Chesneau[24] and Aron.[25] The industry in New South Wales, Queensland, has been written up in the report of Atkinson[26] and Ball,[27] with statistics for New South Wales from 1865 to 1914. The methods of retorting oil shale past and existent at the present time, with statistics, yields of products in Scotland and Canada, have been covered in detail by Ells,[28] Baskerville,[29] Redwood,[30] Bacon and Hamor.[31]

Outline of Scotch Practice

The following is the merest outline of oil-shale practice in Scottish use to-day. For greater detail the reader is referred to the above references. An oil-shale plant consists in the main of shale-breaking machines, retorts, condensers, ammonia and oil scrubber, fire and steam stills, acid agitators, filters for lubricants and wax, sweat pans, refrigerating house for wax and low cold test lubricants, receiving tanks, gas tanks for burning the gas made directly under retorts, ammonium sulphate house, boiler house, pump house and laboratory.

The oil shale in small pieces is passed by means of hutches into iron retorts varying in capacity from one-half to two tons per twenty-four-hour day. A number of types of retorts are in use, varying considerably, some keeping the mass of shale in continuous movement; others simply heating the mass, and dumping the charge when no further gases pass over to the condensers. The temperature of retorting varies, dependent upon the type of shale used, from 400 deg. C. to 700 deg. C. The temperature control is highly important, for upon this factor depends the type of hydrocarbons formed and amount of ammonia, the latter forming in greater quantity when steam is passed into the system toward the end of the reaction. The products resulting from retorting the oil shale pass through air or water-cooled condensers and the uncondensed gases are drawn into exhausters. From the exhausters the uncondensed gas is led through water and oil scrubbers to remove ammonia and light hydrocarbons. The scrubbed gas may be used directly for fuel with a "booster" attached or may be passed to a storage gas tank. The ammonia liquor is distilled and the gas passes through sulphuric acid forming ammonium sulphate crystals which are purified for market or sold dry without purification, dependent upon the use.

The usual commercial products resulting from the retorting of oil shale are crude oil, motor fuel, naphtha, burning oil or kerosene, gas or fuel oil, lubricating oils, paraffin wax, still grease, coke and ammonium sulphate. Table III gives the products and yields for the year 1916 of 3,500,000 tons of oil shale retorted in Scotland.

Table III—Scottish Shale Products Obtained and Products Marketed in 1916 from 3,500,000 Tons Oil Shale

	Gallons	Per Cent Basis Oil Recovered	Approximate Specific Gravity	Approximate Beaumé Gravity
Amount crude oil recovered	80,500,000		0 91	23 8
Motor spirit	600,000	0 7	0 74	59 2
Naphtha	4,340,000	5 1	0 78	49 5
Burning oil	22,000,000	28 5	0 82	40 7
Gas or fuel oil	13,000,000	16 2	0 86	32 8
Lubricating oil	11,000,000	13 7	0 90	25 5
Paraffin wax (tons)	27,500	1 0	110 -132°	
Coke	84,000	3 0		
		Basis Ton Oil Shale Used		
Ammonium sulphate (tons	59,400	1 41		
As ammonia (tons	16,000	0 44		

The average cost per ton of oil-shale mining and retorting was $2.00, and the net profit per ton oil shale retorted $0.85. In the year 1916, 23 gal. of oil and 38 lb. of ammonium sulphate as an average were produced for each ton oil shale retorted.

The Comparative Yields of Oil and Ammonium Sulphate from Retorted Oil Shale

The vital figures in oil-shale mining are those which will give average gallons of oil and pounds of ammonium sulphate per ton of oil shale retorted. For upon the yields of the crude oil and sulphate depends the question whether a plant will be remunerative financially. Winchester[32] in his important contribution to oil shale information has shown that of 132 samples retorted the yields of oil per ton of shale ranged from 0.31 to 90 gal., and the pounds of ammonium sulphate from 0.4 to 12.69 dry retorted. He has worked out a con-

[23] Bulletin 641 U. S. Geol. Survey.
[24] Annuales des Mines, 6th series, 19, 347, 1891.
[25] Annuales des Mines, 9th series, 4, 67, 1913.
[26] Annuales des Mines, 10th series, 9, 47, 1906.
[27] New South Wales, Dept. Mines, Ann. Report, 1865-1910, 1911, to 1914.
[28] Queensland Govt. Min. Jour. 16, 605, 1915.
[29] Canada Dept. of Mines, Summary Report, 1908, 1909.
[30] Canada Dept. of Mines, Summary Report, 1909. Royal Soc. Canada Trans. 3rd series, 3, 35, 1909. N. Scotia Min. Soc. Jour., 15, 29, 1910. Eng. and Min. Jour., 88, 149, 195, 1909. Cons. Inter. Chim. App. Comp. rend., 4, 22, 1910.
[31] Redwood, Treatise on Petroleum, 2, 483, 1913.
[32] The American Petroleum Industry, 2, 807, 1916.
[33] U. S. Geol. Survey, Bulletin 641, 1917.

version factor when the shale is steam-distilled for ammonia which brings the ammonium sulphate values from one to thirty-two pounds per ton shale retorted.

In Table IV the writers have computed the average of fifty-one samples retorted Colorado shale, which gave an oil gallonage of 16.2. Of the fifty-one samples twenty-nine were tested for ammonium sulphate with an average of 7.6 lb. per ton of shale. For the state of Utah the average of thirty-eight samples under similar conditions gave 25 gal. of oil and 5.3 lb. of ammonium sulphate per ton. Wyoming gave 16.4 gal. oil and 6 lb. of ammonium sulphate per ton as an average of forty-two samples retorted. The oil shales of Utah indicate a 40 per cent greater yield of oil per ton than the states of Colorado and Wyoming. Twenty samples of the Colorado shales were tested for the cubic feet of gas per ton of shale retorted, and the average was found to be 2705.

The distillation analysis of nine samples of shale oil from divergent geographic locations have been averaged. The gasoline cut percentages ranged from 6 to 12; the kerosene cut from 28.5 to 49 and paraffin from 1.63 to 7.70, while the unsaturated hydrocarbon in the kerosene cut ranges from 55 to 71 per cent. Although an average over the samples of 9.6 per cent with a Beaumé gravity of 47.9 for the gasoline cut is noted, this is quite different from having 9.6 per cent of an oil which will be suitable for internal combustion engines. It is highly questionable whether in refining and redistilling the above gasoline cut into a motor fuel suitable for internal combustion engines that anything like 9.6 per cent of marketable motor fuel would be obtained from 100 gal. of oil shale as typified by the samples analyzed. The Scottish oil-shale industry for 1916 marketed 600,000 gal. of motor fuel of 59.2 Beaume gravity, which was 0.7 per cent of 80,500,000 gal. of shale oil produced.

TAPLE IV—THE AVERAOE GALLONS OF OIL, POUNDS OF AMMONIUM SULPHATE AND CUBIC FEET OF GAS PER TON OF OIL SHALE RETORTED FROM UTAH, COLORADO AND WYOMING[32]

Source of Oil Shale	Number of Samples	Average Gallons Oil per Ton Shale	Average Pounds Ammonium Sulphate per Ton Shale	Average Cu. Ft. Gas per Ton Shale	Specific Gravity Oil	Beaumé Gravity Oil
Colorado.	51	16.2	(29 samples) 7.6	(20 samples) 2705	0.9032	25.0
Utah.	38	25.0	5.3	.....	0.9026	25.1
Wyoming.	42	16.4	6.0	....	0.8997	25.6
Average of all samples	131	19.2	6.8	.....	0.9018	25.2

AVERAOE DISTILLATION ANALYSIS NINE SAMPLES

	Per Cent	Specific Gravity	Beaumé Gravity
To 150 deg. C. (gasoline cut)	9.6	0.7871	47.9
150 to 300 deg. C. (kerosene cut)	37.3	0.8601	32.8
Asphalt	2.0	.....	....
Paraffin	4.9	.....	..
Sulphur	0.8	.....	..
Nitrogen	1.68	.....	..
Unsaturates in (kerosene cut)	61.5	....	

G. H. Ashley[34] of the Geological Survey has reported upon the black shale of Eastern United States. The lowest yields were noted in West Virginia of 1.4 gal. oil and the maximum of 27.6 for the state of Pennsylvania per ton black oil shale retorted. The latter figure compares more than favorably with the average of Utah and gives a 42 per cent higher oil yield than the states of Colorado and Wyoming.

The data are compiled in Table V.

At least three important factors enter into the profitable mining of black oil shale:

1. Where the out croppings permit of steam shovel use at a minimum of cost.
2. Where the coal is overlaid with oil shale which can be mined at the same time.
3. Where oil shale must be removed to mine the coal and can be retorted at same time.

Ashley has stated that the total area of southeastern Indiana is underlain with shale bearing oil, which contains 100,000,000,000 barrels of oil.

TABLE V—THE AVERAGE GALLONS OF OIL PER TON OF BLACK SHALE RETORTED FROM THE EASTERN PART OF THE UNITED STATES[34]

Source of Oil Shale	Number of Samples	Average Gallons Oil per Ton
New Albany, Ind., Boonville, Ind	7	10.0
Springfield, Ill., Gallatin, Ill.	2	14.0
Crittenden, Ky., Louisville, Ky., Caseyville, Ky.	3	5.1
Glen Mary, Ohio; Columbus, Ohio; Gahama, Ohio.	4	7.1
Cannelton, Pa., Clay Township, Pa., Queen Junction, Pa., Butler, Pa., Zelienople Quadrangle, Pa	7	27.6
Cumberland Gap, Tenn., Rockwood, Tenn., Bakers Station, Tenn., Newson, Tenn., Newcomb, Tenn.	13	5.2
Hancock Station, W. Va.	5	1.4
The average of all black shales retorted	....	12.5

The oil shale investigation of Canada has been covered by Dr. R. W. Ells of the Department of Mines, Canada, in a thorough manner. These show a much higher yield of oil and ammonium sulphate than those investigated in the United States. The average yield of oil for forty-four samples for Canada is 34.9, while an average of 131 samples in the United States gave 19.2 gal. per ton. The yield of ammonium sulphate for Canada gave 51.3 lb. and 16 lb. for the United States. Table VI tabulates the data in detail.

TABLE VI—THE GALLONS OF OIL AND POUNDS OF AMMONIUM SULPHATE PER TON SHALE RETORTED. EASTERN CANADA[35]

Source of Oil Shale	Number of Samples	Imperial Gallons per Ton	U. S. Gal. per Ton	Specific Gravity	Pounds Ammonium Sulphate per Ton
Albert Mines	5	40.6	48.7	0.893	59.4
Frederick Brook	4	31.4	37.7	0.890	40.4
Dover	4	27.4	32.9	0.921	29.5
Taylorville	7	44.2	53.0	0.905	95.9
Baltimore	4	49.9	59.9	0.893	71.1
Prosser Brook	1	30.0	36.0	0.895	75.0
Goshen	1	27.5	33.0	0.897	36.0
Maple and Elgin	2	7.0	8.4	0.891	(a)
McLellan Brook	9	15.9	19.1	0.897	30.2
Antigonist	4	13.5	16.2	0.901	27.9
Gaspe Quebec	3	32.2	38.6	0.948	47.3
Average of all samples	44	29.1	34.9	0.903	51.3

(a) Not determined.

Since cannel coal is analogous to some extent to oil shale, for comparative purposes some work by Ashley[37] and Ingram[38] on cannel coal has been given, the data of which are shown in Table VII. An average of thirteen samples gave 38.8 gal. of oil, which is 100 per cent higher than the average yield of Utah, Colorado and

[32]U. S. Geol. Survey, Bulletin 641, L, 1917.
[34]Geol. Survey, Bulletin 641, L, 1917.
[35]Geol. Survey, Bulletin 641, L, 1917.
[36]R. W. Ells, Geol. Sur. Branch Dept. Mines, Canada, Vol. 26, 300, 1909.
[37]U. S. Geol. Sur., Bulletin 641, L., 1917.
[38]Bulletin School of Mines, University of Missouri, 1917.

Wyoming. This oil from distillation analysis compares favorably with the oil from shale. The geological data as to the size and extent of cannel coal deposits in the United States are not obtainable to any extent. In the Caney Creek[39] region of Kentucky there is a workable section of cannel coal of 2000 acres. The writers have calculated that this area would produce approximately 10,000,000 barrels of oil and 11,000,000,000 cu. ft. of gas.

TABLE VII—THE AVERAGE GALLONS OF OIL, POUNDS OF AMMONIUM SULPHATE AND CUBIC FEET OF GAS PER TON OF CANNEL COAL RETORTED FROM PENNSYLVANIA, MISSOURI AND ILLINOIS

Source of Cannel Coal	Number of Samples	Average Gals. of Oil per Ton	Specific Gravity	Cu. Ft. Gas per Ton	Beaumé Gravity	Pounds Ammonium Sulphate
Indiana Co., Pa.; Armstrong Co., Pa.; Annelton, Pa.[1]	5	29 6		4885	.	17 2
Wainwright, Mo.; Princeton, Mo.[2]	6	51.4	0 914	7193	23.2	(a)
Herrin, Ill.[2]	2	34 6	0 912	4440	23 5	(a)
Average of all samples	13	38 8	0.913	5506	23 4	.

(a) Not determined.
(a) Not recorded.
[1]Ashley U. S. Geological Survey Bulletin, 641 L., 1917.
[2]Ingram Bulletin School of Mines University of Missouri, 1917.

The oil-shale industry in France began in 1830 with a commercial process perfected by Selligue in 1839. The industry flourished until 1864 when it received a shock similar to Scotland, due to the introduction of American petroleum in 1864. American and Russian refined petroleum products practically paralyzed the oil-shale industry from which it took a long time to recover. The oil-shale retorting practice of France was for many years in oil productivity much lower than Scottish practice. The French practice was to retort at a relatively low temperature, no steam being used during cracking for increasing the yield of ammonia. It was not until 1903 that the Young and Fyfe retorting method was installed in French practice. The advantages of this method over the older one were that it allowed of a saving of fuel and increased the ammonia and oil yield. In Table VIII the gallons of oil per ton of oil shale retorted over a period of years is given. The immediate effect of the Young and Fyfe method of retorting is shown clearly in the year from 1903 to 1904, where the oil yield jumped from 18.1 to 20.7 gal. of oil per ton of shale.

Aron[40] states that by the introduction of steam and higher temperatures in oil-shale retorting practice in France a saving of 80 centimes per hectolitre of oil was accomplished. In the Autun and Allier districts in 1893 there were 96 plants in operation with 414 French retorts and no Scotch; while in 1905 of the 74 plants in operation there were 232 Scottish retorts and only 60 French. It is more than likely that at the present time Scottish retorting is in vogue in all plants in France.

The production over a series of years as shown in Table VIII gives a steady increase in gallonage of oil per ton of shale retorted due to improved methods of retorting. But, the amount of oil produced per year is negligible in comparison to the oil requirements of France and also shows a decline in oil shale retorted. Edouard[41] in 1915 stated that "France, which does not produce petroleum at all, is obliged to get from foreign countries all she consumes." In the *Annales des Mines* for the latter years no statistics of oil shale or products resulting therefrom are given. Beranger[42] in July, 1917, proposes that France coke coal for the production of gas and oil, the latter to be used for the industries and fuel for ships. He emphasizes the utter dependence of France in peace as well as war times upon foreign countries for petroleum products and advises the government to seek oil production in Persia and other countries so as to preserve the economic life of France. The needs of France in this respect are 30,000 tons of gasoline for the army and 20,000 tons for the interior per month. This amounts to 225,000,000 gal. of gasoline a year as the needs of France. The total oil produced from shale was in round numbers 3,700,000 gal., of which probably 2 per cent was gasoline or 74,000 gal. of gasoline, which is practically a negligible quantity in comparison to the 225,000,000 gal. gasoline required yearly in France.

TABLE VIII—TONS AND OIL PRODUCTS FROM FRENCH SHALE

Year	Shale Retorted (in Tons	Oil Produced (Hectolitres	U S Gallons	U S Gallons per Ton
1893	186,040	97,820	2,584,111	13 9
1894	185,617	94 457	2,495,271	13 6
1895	216,079	106,958	2,825,410	13 1
1896	178,571	109,415	2,890,795	14 9
1897	190,302	114,703	3,031,094	15 9
1898	181,988	109,903	2,904,302	16 5
1899	209,125	131,865	3,483,478	16 7
1900	220,609	134,191	3,544,923	16 1
1901	208,070	131,612	3,476,794	16 7
1902	212,955	141,821	3,746,459	17 6
1903	185,280	136,136	3,596,304	18 1
1904	184,030	139,826	3,693,783	20 7

The oil shale industry in New South Wales[43] is approximately sixty years old. The method of retorting is the Scotch one, which up to the present is the most successful in use. The industry in New South Wales has declined markedly in the last twenty years, droping from 59,426 tons in 1895 to 17,425 tons oil shale retorted in 1916. The amount of oil produced per ton of shale retorted was not obtainable, but on the assumption of 20 gal. of oil per ton of shale, 348,500 gal. of oil would be produced. The data in Table VIII-A expresses the tons of oil shale retorted from 1865 to 1916 and the value per ton in pounds sterling.

TABLE VIIIA—TONS OF SHALE RETORTED IN NEW SOUTH WALES, YEAR 1865-1916

Year	Quantity, Tons	Total Value in Pounds Sterling
1865	570	2,350
1875	6,197	15,500
1885	27,426	67,239
1895	59,426	75,218
1905	38,226	21,246
1915	15,474	12,890
1916	17,425	17,772

Independence, Kas.

Chihuahua Smelter Re-opens.—The American Smelting and Refining Co., reopened its smelter near Chihuahua, Mexico, on March 31st, after a shut-down lasting since November 1915. About fifteen Americans and 500 Mexicans are at work, which number will be doubled shortly if conditions seem to warrant the step. The Americans are housed in Chihuahua City, and taken to and from work in automobiles.

[39]Kentucky Geological Survey, Bulletin, 10.
[40]Annales des Mines, 10th series, 9, 47, 1906.
[41]L' E'conomiste Francois, Paris, July, 1915. Vol. 2, p. 3, "Le Petrole La Production," etc.
[42]L'Echo des Mines, 1917.
[43]New South Wales Mines Dept. Annual Reports, 1914-1916

A Process for Deodorizing Fatty Oils

By WALTER P. SCHUCK*

IN THE preparation of vegetable and animal fats and oils for commercial use a large portion of these substances is treated by some deodorizing process in the course of refining. According to Lewkowitsch,[1] one of the earliest methods of deodorizing oils was by heating them to a high temperature. This method will destroy the characteristic odor of many oils if the temperature employed is high enough. Many recent attempts have been made to apply this method to the deodorization of fish oil on a commercial scale in Europe. While the characteristic odor of an oil may be destroyed by heating, a more or less burnt or other unnatural odor is usually developed and therefore the method has not been used for the preparation of edible oils.

The process commonly used to deodorize an oil without changing any of its properties except odor and taste, consists in blowing live or superheated steam through the oil for a sufficient length of time to secure the desired result. This process is effective only on those oils whose odor and taste are due to the presence of small quantities of substances that might be classed as impurities and are carried away by the steam. That is to say, if oils are considered as essentially mixtures of the glycerides of fatty acids, the steam-deodorizing process is effective only when the characteristic odor is not due to one of the constituent glycerides. Fortunately the steam-deodorizing process has made it possible to obtain odorless and pleasant tasting oils from nearly all vegetable oils that were desired for edible purposes. Fish and marine animal oils, however, cannot be completely and permanently deodorized with steam.

Despite the wide application of the steam-deodorizing process it is well known that the conditions to which this process subjects the oil are such as to promote decomposition. The action of hot water or steam has been used to hydrolyze fatty oils into glycerine and fatty acids, high pressure being advantageous in the process. This pressure is not present when deodorizing with steam. The contact of steam and oil at a high temperature does exist and tends to set free the fatty acids. This does not cause the oil to take on a rancid taste or smell immediately; it does tend to develop rancidity later.

About two years ago while the author was carrying on some experiments on the catalytic hydrogenation of naphtha-extracted corn oil, he observed that a sample which had not been purified sufficiently to allow the catalyzer to act and which had not hardened, nevertheless was rendered odorless and palatable by the action of the hydrogen on the oil containing a catalyzer in suspension. Although no appreciable hardening had taken place, the improvement in odor and taste was so marked that a fresh sample was treated under identical conditions except that no catalyzer was present. This sample proved to be equal in odor and taste to that treated with hydrogen in the presence of a catalyzer and thus showed that the catalyzer did not function in the removal of odor from the corn oil.

Knowing that fish oils had not been deodorized unless they were at least partially hydrogenated in the presence of a catalyzer, the treatment with hydrogen only was next tried on a fish oil. After several attempts the proper conditions were ascertained and a sample of fish oil was produced that was odorless and palatable.

The method of deodorizing any oil or fat by this process consists of blowing hydrogen, or a gas whose principle constituent is hydrogen, through the heated oil and allowing the hydrogen with the entrained vapors from the oil to escape freely from the containing vessel until the desired result is obtained. In the commercial application of this process, the fatty acids and other fumes are condensed and washed from the hydrogen which is thus completely purified and used over again. The entire apparatus should, of course, be filled with hydrogen to the exclusion of all oxygen from the air at the time of its first use. Thereafter each new batch of oil is introduced and the deodorized oil withdrawn through pipes so that no air enters the apparatus. A means of drying the hydrogen is provided in the gas-purifying system if the oil being treated contains appreciable quantities of water.

Chemical and Physical Means Used

The means whereby the deodorization is accomplished in this process are both chemical and physical. The iodine value of the oil treated is lowered to a certain extent and the amount of lowering is proportional to the original iodine value. The process can be successfully operated when the oil comes in contact with nothing but glass and hydrogen during treatment. As far as I have been able to ascertain, glass cannot act as a catalyzer and assist the chemical union of hydrogen with the glycerides of unsaturated fatty acids. Nevertheless I have conducted numerous tests in which an oil was subjected to the action of a stream of hydrogen in a glass distilling flask and have found that the oil so treated is more nearly saturated with respect to hydrogen than the untreated oil as is shown by the lowering of the iodine value. This would indicate that a small but effective portion of the hydrogen actually combines with the oil. This was suspected from the fact that fish oils treated by this process are as effectively and permanently deodorized as they are when subjected to catalytic hydrogenation. A trace of the oil and practically all of the free fatty acids contained in it are mechanically carried away from the oil during treatment. Hence the assumption would not be justified that hydrogen is actually combined with the oil just because the iodine value is lowered. The iodine value might be lowered also if the material carried away was of a more highly unsaturated character than the untreated oil.

To determine more accurately what takes place during

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[1]Volume 3, page 19.

this process, a number of experiments were carried on in which two samples of each oil were subjected to the action of a stream of pure hydrogen and pure nitrogen, respectively, under identical conditions. The fumes carried away from the oil were condensed from the gas and at the end of the experiment practically the entire weight of the oil subjected to treatment was accounted for in the weight of oil remaining in the flask plus the weight of condensate. The iodine values of the remaining oil and of the condensate were determined in each case. It was thus found that in every comparative test the total iodine absorptive capacity of the remaining oil plus condensate was less when hydrogen had been used than when nitrogen had been used. In other words, the iodine value of the total oil body in contact with hydrogen was in every case lower than the iodine value of the oil body in contact with nitrogen, although no metal that might have acted as a catalyzer was present. It would seem from these experiments that my deodorized oil so closely resembles an oil deodorized by catalytic hydrogenation because the two processes are essentially the same; that is, the deodorization taking place in this process is at least partly due to hydrogenation. It has been claimed by Tsujimoto[2] that the odor of fish oils is due to the glyceride of clupanodonic acid which has four unsaturated carbon atoms. As this is only a minor constituent of the oil and since the introduction of hydrogen at only one double bond would change it to a different and probably inodorous compound, it is easy to comprehend how a slight addition of hydrogen to fish oil can make it permanently inodorous.

In the comparative tests above described it was found that nitrogen left the oils with a burnt taste and in some cases with only part of the characteristic odor removed. The free fatty acids remaining in the nitrogen-treated oils is about three times as much as in the hydrogen-treated oils.

An interesting and valuable feature of this process is the rapidity with which free fatty acids are removed from the oil by the stream of hydrogen bubbling through it. These fatty acids begin to pass from the oil at about 240 deg. C. and can be removed from most oils to within 0.15 per cent in 20 min. at 275 deg. C. Cocoanut oil containing over 14 per cent free fatty acids has been purified by this process to a free fatty acid content of 0.12 per cent. A fish oil containing 5.14 per cent f.f.a. was purified by this process so that it contained only 0.14 per cent f.f.a. and the total shrinkage during the hydrogen treatment was only 6.10 per cent. The removal of free fatty acids took place during deodorization. It will be seen that the loss in purifying was only 1.10 per cent more than the loss due to actual removal of free fatty acids. The free fatty acids so removed are condensed from the current of hydrogen and recovered uncombined so that soap can be made from them by neutralizing with soda ash.

In regard to the keeping qualities of oils and fats treated by this process it can be stated that oils so treated stay sweet very much longer than steam-deodorized oils. An exact comparison cannot be made because the oldest samples (treated 21 months ago) are still free from rancidity. A sample of cocoanut oil was treated by this process at the same time that some of the same oil was deodorized with superheated steam in a factory. Both samples were put in clean tins with lids loosely laid on, then alternately kept in a warm place where the oil was liquid during the day and in a cool place at night for four months. The steam-deodorized oil became rancid in a few weeks and was very poor in quality in two months. The hydrogen-deodorized oil was pleasant to taste after four months' storage under the described conditions and is still so. The keeping qualities of hydrogenated oils are well known and since the keeping qualities of oils deodorized by this process are due to the action of the hydrogen, it is not surprising that they should be stabilized and rendered free from the tendency to become rancid.

[2]Journ. Coll. Eng. Tokyo Imp. Univ., 1908—177.

Commercial Possibilities

Among the commercial possibilities of this process the purifying of fish oils so as to render them edible is of prime importance. Even the deodorization of fish oils for technical purposes is a matter of interest. The fish oils deodorized by this process cannot be made to smell of fish by subjecting them to heat or any other action that oils are usually subjected to. While this process cannot take the place of catalytic hydrogenation of fish oils in every case because the oil is not hardened, it is very much cheaper to operate. Fish stearine which is naturally a solid fat at ordinary temperatures can be made into an acceptable cooking fat at very low cost by this process.

Fats which have been burnt from continued use in cooking and have absorbed the odor of fish, onions, garlic, etc., can be rendered perfectly bland and neutral by this deodorizing process. Likewise garbage- and rendering-works grease can be purified so that it is neutral and free from objectionable odor. This latter class of fats usually contain substances that "poison" a catalyzer and therefore are not easily deodorized by catalytic hydrogenation. Since this process does not involve the use of a catalyzer such substances do not interfere.

In the treatment of castor oil this process is of value for two purposes. The medicinal castor oil can be rendered entirely free from its characteristic odor and taste while still retaining its medicinal properties. The lower grades which have a high free fatty acid content can be treated for the reduction of the free fatty acid content and thus render them more acceptable for the lubrication of machinery.

Certain vegetable oils such as soya bean oil are not readily deodorized with steam but are rendered bland and palatable by this process.

It is not to be supposed that every crude fatty oil can be treated by this process just as it is found in commerce nor that low grade greases can be made into light colored, clean fats without more shrinkage than the removal of the free fatty acids would entail. The solid matter, such as particles of cellular tissue, should first be removed by clarification and filtering in order to get the lightest colored product. The total shrinkage will therefore depend on the amount of impurities present and the commercial possibilities can only be determined by a study of the oil or fat under consideration.

The use of the process here described is protected by U. S. Patent No. 1260072 as well as other applications for patent on file and by applications for patent on file in foreign countries.

Synopsis of Recent Metallurgical and Chemical Literature

Experimental Carbon Cell

At the recent meeting of the American Electrochemical Society a paper was read by Dr. S. ALBERT REED of New York City. A primary battery was described in which the electrolyte is fused borax containing manganese dioxide, the negative pole is broken carbon in contact with a graphite grid and floating on the melt, while the positive poles are strips of gold foil. The carbon is kept inside a cylindrical shell of siliceous material (a sawed-off crucible), while the melt is contained in a shallow clay roasting dish, in which the cylinder stands. The air oxidizes the electrolyte in contact with the outer gold strips, while the carbon reduces the electrolyte inside. Mixtures of CO_2 and CO are produced at the anode. The voltage averages 0.8.

Analysis of Ferro-Silicon

Another paper at the convention was on the "Commercial Analysis of Ferro-Silicon" by EARL M. ANGER, research chemist of the Chile Exploration Co., New York City. The author said he had read with much interest papers by a number of writers on the commercial analysis of ferro-silicons of various grades. Nearly all gave long, tedious methods, and not all of the necessary accuracy. Some writers determine several elements and then call the balance silicon. There are several elements which often occur in ferro-silicon of these grades when manufactured from iron ore or iron cinders, which are entirely neglected in this calculation. Any one of these elements may at times contaminate ferro-silicon up to 1 per cent. He then gave personal notes and experiences in the commercial analysis of electric furnace ferro-alloys for carbon, manganese, phosphorus, phosphorus evolved as phosphene, sulphur, iron, titanium, calcium, magnesium, aluminium, barium, and silicon; with advice on sampling. Many samples which he examined contained 0.1 to 0.5 per cent barium.

Electric Steel Castings

In a paper on this subject read at the recent meeting of the American Electrochemical Society by R. F. FLINTERMAN, the author said in part:

"During past months we have been experimenting along this line and wish to refer briefly to some wonderful tests we have been getting from vanadium steel. These tests have been obtained repeatedly, so that we are confident that we can reproduce them commercially.

"The tests we refer to are the following:

	No. 1		No. 2	
Ultimate strengtb.	102,000 lb.	74 kg./sq. mm.	103,800 lb.	74 kg./sq. mm.
Elastic limit.	81,500 lb.	57 kg./sq. mm.	84,000 lb.	59 kg./sq. mm.
Elongation in 2".	23 per cent.		21 per cent.	
Reduction in area.	48 per cent.		47 per cent.	

"There is just one more point which I desire to bring to your attention. In the discussion of my paper before this Society in May, Prof. J. W. Richards spoke in part as follows[1]:

"'Regarding the general question of the fitness of electric furnace steel for steel castings, for the information of the Naval Consulting Board I sent a questionnaire to about forty or fifty of my friends in the steel business, asking how a better class of steel castings could be obtained. About nineteen out of twenty of these answers were that if they would specify electric furnace steel for their castings that, other things being equal, there was a far better chance of getting a fine casting from electric furnace steel than from any other class of steel.'

"This statement of Prof. Richards sounds strangely prophetic, when read at this time in the light of what has happened since these words were spoken. Referring to our own experience, we are furnishing considerable quantities of army castings under Class No. 2 and No. 3 specifications, and are also making navy castings under Class 'B' specifications, and are having little trouble in meeting these specifications.

"We do not want to give the impression that these results are being obtained without any particular effort on our part, for quite the contrary is the fact. The heats are held for analysis before pouring, and every possible effort is made to have carbon and manganese where we desire them, before the heat is poured. Annealing is carefully carried out in new ovens recently installed, and here again every care is taken to see that annealing is exactly what we have planned it to be.

"The result of these precautions is that we are passing army and navy tests regularly. We do not hesitate to say, however, that with the same precautions we would fail on many of the tests were we using converter steel. At least that was our experience when we made converter steel, and it is our belief that many converter foundries are having this same trouble at the present time.

"The tests that we are obtaining are interesting in one way. They rather emphasize the fact that the specifications were not written for electric steel. For instance, Class No. 2 army specifications—

	Call for		We obtain	
Ultimate strengtb.	75,000 lb.	53 kg./sq. mm.	75,000 lb.	53 kg./sq. mm.
Elastic limit.	35,000 lb.	25 kg./sq. mm.	40,000 lb.	28 kg./sq. mm.
Elongation in 2 in.	15 per cent.		20 per cent.	
Reduction in area.	20 per cent.		30 per cent.	

"In the same way Class 'B' navy specifications—

	Call for		We obtain	
Ultimate strengtb.	60,000 lb.	42 kg./sq. mm.	65,000 lb.	46 kg./sq. mm.
Elastic limit.	27,000 lb.	19 kg./sq. mm.	35,000 lb.	25 kg./sq. mm.
Elongation in 2 in.	22 per cent.		30 per cent.	
Reduction in area.	30 per cent.		40 per cent.	

"In addition to the above, a 120-deg. bend test is required, which usually shows a bend up to 170 deg. or 180 deg.

"This army and navy steel-casting experience is really a great education for many of the steel foundries, and is bound to have a marked influence upon the industry after the war. Instead of a statement of hoped-for qualities, competition will demand physical test coupons, which must stand certain tests, and the casting will be accepted or rejected on the basis of these tests. It is needless to add that castings sold under such an arrangement must necessarily be of a uniformly higher grade than the average run of steel castings now sold."

[1]Trans. Am. Electrochemical Soc., 1917, 31, 80.

Personal

Mr. R. E. Parks, assistant general manager of the Aluminum Company of America, Maryville, Tenn., has been promoted to the position of general manager of the company's plant at Vadin, N. C.

Mr. John Joseph Carty, Colonel, Signal Corps, U. S. Army, was the recipient of the Edison medal awarded by the American Institute of Electrical Engineers on May 17, 1918.

Mr. George B. Hogaboom has been granted a leave of absence by the Scovill Manufacturing Company, in order to accept the appointment as electroplating advisor for the Bureau of Standards. He entered on his new duties May 15.

The following changes are announced in the Department of Chemistry in the College of the City of New York: Assistant Professor F. E. Breithut, who has already been granted a leave of absence for the duration of the war, has been commissioned as Captain in the U. S. Army, and has already reported for duty. Dr. B. G. Feinberg, Tutor in Chemistry, has been appointed Research Chemist in the Ordnance Division of the United States Army, and ordered to report for duty May 17. Mr. D. L. Williams, Instructor in Chemistry, has been called into the National Service to be in charge of the Division of Supplies of the Research Department of the Gas Warfare Section of the United States Army, to report by June 1 at the latest. Mr. Paul Gross, Tutor in Chemistry, has been commissioned as Second Lieutenant in the United States Army, and was required to report for duty in Washington on the morning of May 9.

Mr. H. Kenyon Burch, who has been connected with the Inspiration and Miami Companies at their Arizona concentrators for several years, has been engaged by the Phelps-Dodge Corporation to design and build the 3000-ton concentrator at Bisbee, Arizona, for the Copper Queen Department.

John A. Traylor has resigned from the position of Western Manager of the Traylor Engineering and Manufacturing Company, and will devote his time to his mining interests, with headquarters in Salt Lake City.

Orville R. Whitaker, who conducted the recent investigation into the smelter schedules in force in Colorado, has been appointed by the Dominion government to be an independent judge on a commission to investigate the new schedules of the Consolidated Mining and Smelting Company of Canada, operating the Trail smelter. The appointment of this commission followed representations from the mining men of British Columbia that the new rates would mean wholesale closing of mines in their province.

Current Market Reports

Non-Ferrous Metal Market

Thursday, May 23—A hearing has been called for at San Francisco by the U. S. Tariff Commission to be held during the week of June 24 to deal with tungsten, quicksilver, antimony and their manufactures.

Antimony.—This metal was in better demand and business of considerable magnitude was done. We quote spot at 12¼@12½c. for the week, with 12½c. at the close.

Chrome.—The Western sellers of this ore have slightly reduced their price and are now more in line with the Eastern market. The latest offers from the West are at $1.50 to $1.55 for 45 per cent Cr_2O_3 f.o.b. shipping point.

Copper.—Prime Lake, Electrolytic and Casting are quoted at $23.50, Government price.

Lead.—There has been no change in the lead market during the last week. The price of 7c New York is maintained; outsiders are quoting slightly above that figure.

Manganese.—Unchanged at $1.20@1.30 per unit for metallurgical ore, 48 per cent grade.

Molybdenum.—Unchanged at $1.15 per pound for 90 per cent grade.

Spelter.—Prices on spelter are quoted at 7¼c. to 7½c. per pound, New York delivery. The Government has fixed the following maximum prices for zinc, subject to the trade discounts and differentials in effect Feb. 13, 1918: Grade A, 12c.; plate, f.o.b. plant, 14c.; sheet, f.o.b. plant, 15c.

Tin.—In view of the clearer position as to shipments of Banca tin to this country the tin market has eased off a little and the London price has now been reduced to £363 per ton. The spot market is exceedingly firm and prices well in excess of $1.00 have been paid for early deliveries.

Tungsten.—Unchanged at $24.00 for scheelite. Tungsten ore of an inferior grade, though available only in small quantities, changed hands at prices according to quality from $20.00 to $23.00.

OTHER METALS

Aluminum, lb., 98-99 per cent., virgin, Government price	32
Bismuth, lb	2 50 3 50
Cadmium, lb	1 40 1 50
Nickel, electrolytic, lb	40
Silver, oz. (official)	99
Platinum, oz	105 00
Palladium, oz	135 00
Cobalt, lb	2 50–3 50
Magnesium, lb	2 00
Quicksilver, Cal	125 00
Quicksilver, Mexican	118 00

The Iron and Steel Market

May has easily been the steel industry's banner month in production, production of ingots having been at the rate of about 45,000,000 tons a year. The best record previously was a rate of 44,400,000 tons, last November. Production in January was at a rate below 30,000,000 tons. Production of finished rolled steel is approximately 75 per cent of the production of ingots. Prior to the war the proportion scarcely varied by one per cent, from 76 per cent, taking a year as a whole, but 1916, with its large production of shell steel, involving heavy discards, brought the proportion down to 75 per cent.

While the steel industry usually sees its heaviest production in March and October, the high point was reached later this year, as the railroads were still in poor operating condition in March.

Pig Iron and Scrap

There is a curious coincidence in the matter of relative production of pig iron and steel ingots. In 1916, the last year for which complete data are available, the production of pig iron was 39,400,000 tons and the production of ingots 41,400,000 tons, showing 2,000,000 tons more ingots than pig iron. A considerable part of the pig iron produced was used in foundries, while on the other hand the steel-making departments used a great deal of scrap, the one tending to balance the other. While there is a wide divergence between the production of steel ingots and the production of finished rolled steel, for many years the production of finished rolled steel has been almost precisely equal to the production of steel-making pig iron, the use of scrap arising outside the steel works approximately making up the carbon and silicon losses from the weight of pig iron as well as the scale produced and other material lost beyond recovery by the open-hearth steel furnace.

Now in April of this year the production of pig iron was at the rate of about $40,400,000 tons and the production of steel ingots at the rate of about 42,650,000 tons, showing approximately the same divergence as was shown in 1916. The coincidence is fortuitous, however. Undoubtedly much less pig iron is being consumed in foundries this year than was the case in 1916, and it follows that the consumption of scrap has been correspondingly less. This is a reflection of the known market condition that scrap is scarce. There is very little old material being brought out, because there is little wrecking of railroad rolling stock and of old bridges and buildings. It is true that there is much shell steel being produced, but that is a condition that obtained in 1916 also, and presumably of late all the scrap possibly applicable to the rolling of commercial steel have been so used. The steel has been rolled into light rails, concrete reinforcing bars, bedstead angles and similar forms, being particularly in request on account of the light supply of old rails for rerolling.

With the insistence of the Government upon a maximum diversion of steel to war purposes it is probable that the employment of shell discard steel in these directions will decrease, the material being forced into the open-hearth furnaces even though from the pecuniary standpoint it is more valuable when rolled into merchantable product. Profits cannot be considered in this connection. Were there not this expectation it is doubtful whether the steel-making units could hope to operate at capacity, for the steel ingot capacity in existence is fully 47,000,000 tons, and it may be a couple million tons more, while the blast furnace capacity can hardly be much in excess of 43,000,000 tons.

War Steel

Since early in April, when the Washington authorities began insisting that the steel industry divert every ton of steel to war work that could possibly be used in filling war orders, there has been an increasing diverting of steel in that direction, and a diminution in shipments to ordinary commercial industries, even though the total production has been increasing steadily.

The great question has been how much steel the war items could possibly use. The insistence upon maximum shipments is no criterion, for the reason that as a measure of safety it is desired that the various war activities be stocked up, and an eye is also held on next winter, when there may be a partial recurrence of the distressing blockade of last winter. Shipbuilding, for instance, may be consuming at the present time less than 200,000 tons of steel a month, but a million tons could easily be accumulated to advantage at the scores of fabricating shops that are serving the shipyards making fabricated ships, and at the shipyards with their hundreds of shipways.

For a clearer insight into this matter, and for a more efficient distribution of the steel as produced, there was appointed on May 17 a joint committee of representatives of the Government and of the steel makers, to go into this whole subject. The committee will gather additional information, and will besides view the matter from a somewhat new angle, the question of time as well as tonnage being considered. Hitherto the orders and requirements of the Government have been stated precisely in terms of tons, but quite indefinitely in terms of delivery periods.

In the past few weeks the matter of steel for shipbuilding has been one of shipping the maximum tonnage possible, irrespective of the rate of current consumption. The steel industry has been expecting that sooner or later the shipbuilding industry would become so stocked that a curtailment would be called in the rate of shipping. Whether this will be the case or not, the announcement in the past fortnight of the shipbuilding program for 1919 gives a more specific suggestion as to the prospects as to the rate of consumption than has hitherto been available. The program involves 3,000,000 tons deadweight of wooden vessels, requiring but a modicum of steel, and 12,000,000 tons deadweight of steel vessels, requiring about one gross ton of finished rolled steel for three tons deadweight vessel capacity. Thus, apparently, the contemplated rate, when shipyards are all working, will involve some 350,000 gross tons a month of rolled steel, which may be compared with about 2,800,000 tons a month production at the latest rate. Very nearly all the capacity available for rolling heavy sheared plates will be engaged, but the contribution of other departments will be light. Shell steel requirements may run 200,000 to 400,000 tons a month. The 100,000 freight cars recently ordered will require fully 1,000,000 gross tons of rolled steel, axles and wheels. Fabricated steel requirements will be heavy for months but this demand will hardly continue. For various requirements large tonnages of sheets and other material are called for. In the long run, however, it seems altogether improbable that all direct war activities will consume much more than half the steel produced.

It has become clearer and clearer, however, that there are scarcely any really nonessential industries, normally consuming steel. Nearly all are more or less helpful, indirectly, towards winning the war. Accordingly, the so-called "commercial" steel is to be distributed according to the relative importance of commercial industries. Already steel for oil production and transport and for agricultural pursuits is being given first preference after war and railroad orders.

A very large tonnage of steel is to be sent abroad. General Pershing has made quite a reputation as a borrower, having borrowed from France and Britain steel in various forms which he has called upon the Government to repay, in the sum of about 1,250,000 tons of steel. There is no longer a measure of the steel that leaves the country, as in the familiar statistics of exports there does not appear the cargoes of vessels owned or chartered by the Government. They do not clear in the usual manner, and the steel they carry, no matter who is the consignee, does not appear as exports.

Chemical Market

Coal Tar Products. The demand for crudes has eased off greatly with considerable change made in prices because of the offerings at price concessions. The intermediates continue to be in good demand, with prices generally unchanged, although inclined to be firmer.

Benzol: Prices have undergone changes because of the surplus offerings which have weakened the tone of the market. Consumers are apparently not interested at present and are awaiting further market changes.

Phenol: The demand continues light with much larger supplies of material coming on the market, as producers who have been giving over their entire output to the government are now offering in the open market. Prices have registered declines.

Toluol: There have been releases made to benzoate of soda producers at varying prices. There is a better prospect in view for the spot market as offerings may become more plentiful should the government permit the release of any quantities of surplus toluol.

Naphthalene: The situation continues to be quiet with considerable ease. Offers have been very liberally made and in order to move material price concessions have been made.

Benzoate of Soda: In the face of offerings of larger quantities of material and the releases being made to producers under government sanction the market has eased up. Prices are lower with a restricted demand.

Dimethylaniline: Production continues to be confined to a few producers. Prices are holding firm with a fairly active demand.

Paranitraniline: There are only few sources of production, although the requirements of the market are being met with. Prices are firm and seem to be inclined higher.

Aniline Oil: Business of moderate proportions is passing Prices are slightly easier.

Beta Naphthol: The demand has lightened, although still of fair proportions. There is little change in the sublimed grade, the price of which is quotably unchanged. The technical grade is the more active.

Alpha Naphthylamine: An easier tone is to be noted and prices have gone a little lower. Supplies that are fairly large are available.

Metatolumylenediamine: The demand is active but not heavy. Production has been helped by the releases of toluol.

Para Amido Phenol: Production of ample proportions is being maintained with prices unchanged.

Phthalic Anhydride: The tone shows no change and is firm. Prices are holding at the same levels.

Heavy Chemicals: Not a great deal of important change is noted one way or the other on any of the items that fall under this classification, and for the most part the condition has been comparatively slow, with prices ruling at slightly lower levels than were previously noted for some items. After several days of inactivity, caustic soda was reported slightly improved late at the close, but its neighbor, soda ash, has failed to respond in sympathy, and wide price ranges continue to be heard on account of considerable speculation as to futures. All acids continue in scant supply in the open market.

Caustic Soda: Business in the New York market on this item has been chiefly of a routine character, but factors reported a slight improvement late at the close in view of

a better inquiry from the majority of large consumers. On spot prices ranged from $4.25 to $4.50, but perhaps on firm bids even these figures could be shaded because there are apparently sufficient supplies on hand to take care of a better consumer demand. Not a great deal of additional interest is being displayed on forward positions and prices are quotably unchanged on contracts for over the year in the neighborhood of 4.60 works. For 1919 business from 3¼c. works is the figures most generally heard for the 60 per cent, but little business is noted for this position.

Soda Ash: This item continues to be neglected by the majority of users, and prices continue at lower levels than have been named for a long time. For stocks in bags prices for spot were practically at unchanged levels of a week ago of 2.15 store. Ash in barrels is of little interest at this writing to consumers and closing figures were at 2.60 and up to 2.70, according to quantity. Little underlying strength is noted on account of comparatively light inquiries.

Acetic Acid: For the most part all acetic acid is nominal on account of large requirements from the Government for this material. Little, therefore, is reaching the open market and sales that have been recorded have passed at higher levels than have been noted for some time. The demand is heavy from all directions and the principal accomplishment in practically any degree of this product is that of locating supplies. During the interval sales have been recorded on the 28 per cent material as high as 16¼c., barrels inclusive, and 35c. for the 56 per cent material, barrels extra. Not in a long time has there been such a tight condition as is now noted on acetic acid.

Sulphuric Acid: All sulphuric acid reported as unchanged from the condition that prevailed in this market a week ago. Very few offers of the 60-degree material are noted, and as a rule the buyer continues to prefer 66-degree material when same is available at a favorable figure. In some quarters it is stated that prices for stocks on spot of the 66-degree brimstone acid have advanced, but in second hands sales have been noted as low as $32.50 per ton in sellers' tanks works. Some of the large producers, however, continue to ask as high as $34.00 a ton sellers' tanks works for the ordinary run of business.

Oleum: For tank cars possibly $55.00 is workable. Some business in 60 per cent oleum at $225.00 per ton, and up, but it appears that the production has now been disposed of, and few new orders have been heard at this figure. The situation apparently continues to improve and large offerings are less frequently heard, but in view of a decidedly unsettled condition comparatively wide price ranges continue to be heard.

Yellow Prussiate of Soda: The production of this material continues to be confined to a few firms and is seemingly not sufficiently large to take care of all the business that is now being placed. Prices for spot and nearby stocks are decidedly higher at the close and in a number of important quarters as high as 75c. a pound. The inside quotation heard for this material has been at 70c. With additional inquiries there is more underlying strength than has been noted in this market for some time.

Yellow Prussiate of Potash: Domestic stocks are available at $1.20, and up to $1.25, according to quantity. Offerings are not large and supplies, it is reported, are barely sufficient to take care of all the business that is now being placed. The Japanese materials are nominal, since importers are unable to get ample stocks from the Orient to take care of the volume of business noted.

Cyanide of Soda: Business has been confined chiefly to second hands during the interval, and 38c. has been the figure most generally heard from this quarter. The ordinary seller, however, continues to quote firmly at 40c. and up.

Copper Sulphate: The market has been barely steady on this product, and apparently at the close 9¼c. a pound could have been shaded on a firm bid. The inquiry is active, but no large orders have been recorded and the undertone of the market is not particularly strong.

Bichromate of Soda: It is difficult to get a correct line on the prevailing conditions in the New York market on bichromate of soda. Wide price ranges are heard because of an unsettled condition and closing figures were 24¼c. as the inside, and up to 25c. a pound as the maximum. Additional inquiry interest is being manifested daily on this material.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, MAY 24, 1918

Acetic anhydride	lb.	1 50 —	1 60
Acetone, drums	lb.	Nominal	
Acid, acetic, 28 per cent	lb.	Nominal	
Acetic, 56 per cent	lb.	Nominal	
Acetic, glacial, 99½ per cent., carboys	lb.	Nominal	
Boric, crystals	lb.	13½ —	14½
Citric, crystals	lb.	87 —	88
Hydrochloric, C. P.	lb.	Nominal	
Hydrochloric, 20 deg.	lb.	02½ —	02½
Hydrochloric, conc., 22 deg.	lb.	02½ —	03
Hydrofluoric, 30 per cent., in barrels	lb.	06 —	06½
Lactic, 44 per cent	lb.	11 —	12
Lactic, 22 per cent	lb.	06 —	06½
Molybdic, 85 per cent	lb.	3 85 —	
Nitric, 36 deg.	lb.	08½ —	08½
Nitric, 42 deg.	lb.	09 —	10
Oxalic, crystals	lb.	42 —	43
Phosphoric, 42–50 per cent. paste	lb.	08 —	10
Phosphoric, ref. 50 per cent	lb.	26 —	
Picric	lb.	Nominal	
Pyrogallic, resublimed	lb.	3 10 —	3 15
Sulphuric, 60 deg.	ton	25 00 —	27 50
Sulphuric, 66 deg.	ton	32 50 —	35 00
Sulphuric, oleum (Fuming), tank cars	ton	55 00 —	60 00
Tannic, U. S. P., bulk	lb.	1 30 —	1 35
Tartaric, crystals	lb.	86 —	87
Tungstic, per lb. of W	lb.	1 70 —	1 75
Alcohol, sugar cane, 188 proof	gal.	4 93 —	4 95
Alcol, wood, 95 per cent	gal.	90½ —	91
Alcohol, denatured, 180 proof	gal.	68 —	69
Alum, ammonia lump	lb.	04 —	04½
Alum, chrome ammonium	lb.	18 —	19
Alum, chrome potassium	lb.	20 —	21
Alum, chrome sodium	lb.	12½ —	13
Alum, potash lump	lb.	08½ —	09
Aluminium sulphate, technical	lb.	02½ —	03
Aluminium sulphate, iron free	lb.	03½ —	03½
Ammonia aqua, 26 deg. carboys	lb.	26 —	27
Ammonia, anhydrous	lb.	Nominal	
Ammonium carbonate	lb.	Nominal	
Ammonium nitrate	lb.	(Fixed price)	15
Ammonium, sulphate domestic	lb.	07½ —	08
Amyl acetate	gal.	5 00 —	5 25
Arsenic, white	lb.	09 —	12
Arsenic, red	lb.	35 —	40
Barium carbonate, 99 per cent.	ton	80 00 —	90 00
Barium carbonate, 97–98 per cent	ton	65 00 —	67 00
Barium chloride	ton	65 00 —	85 00
Barium sulphate (Blanc Fixe, Dry)	lb.	02½ —	02½
Barium nitrate	lb.	09½ —	10
Barium peroxide, basis 70 per cent	lb.	30 —	32
Bleaching powder, 35 per cent. chlorine	lb.	01 —	02
Borax, crystals, sacks	lb.	07½ —	08½
Brimstone, crude	ton	Nominal	
Bromine, technical	lb.	75 —	
Calcium, acetate, crude	lb.	Nominal	
Calcium, carbide	lb.	12½ —	14½
Calcium chloride, 70-75 per cent., fused, lump	ton	27 50 —	30 00
Calcium peroxide	lb.	1 60 —	1 70
Calcium phosphate	lb.	34 —	35
Calcium sulphate 98-99 per cent	lb.	09 —	09½
Carbon bisulphide	lb.	08½ —	10
Carbon tetrachloride, drums	lb.	15½ —	16
Carbonyl chloride (phosgene)	lb.	1 10 —	1 50
Caustic potash, 88–92 per cent	lb.	83½ —	84
Caustic soda, 76 per cent	lb.	04½ —	04½
Chlorine, liquid	lb.	15 —	18
Cobalt oxide	lb.	1 60 —	1 65
Copperas	lb.	01½ —	01½
Copper carbonate	lb.	30 —	40
Copper cyanide	lb.	75 —	78
Copper sulphate, 99 per cent., large crystals	lb.	08½ —	09
Cream of tartar, crystals	lb.	80 —	82
Epsom salt, bags, U.S.P.	lb.	03½ —	03½
Formaldehyde, 40 per cent	lb.	18½ —	19
Glauber's salt	100 lb.	1 50 —	1 75
Glycerine, bulk, C. P.	lb.	63½ —	64
Iodine, resublimed	lb.	4 25 —	4 30
Iron oxide	lb.	13 —	15
Lead, acetate, white crystals	lb.	17 —	18
Lead, arsenate (Paste)	lb.	15 —	18
Lead nitrate	lb.	15 —	16
Litharge, American	lb.	09½ —	11½
Lithium carbonate	lb.	1 50 —	2 00
Manganese dioxide, U. S. P.	lb.	70 —	75
Magnesium carbonate, technical	lb.	10½ —	11
Nickel salt, single	lb.	14 —	15
Nickel salt, double	lb.	12 —	14
Phosgene, see Carbonyl chloride			
Phosphorus, red	lb.	1 30 —	1 50
Phosphorus, yellow	lb.	1 50 —	1 60
Potassium bichromate	lb.	44 —	46
Potassium bromide granular	lb.	1 35 —	1 50
Potassium carbonate calcined, 85-90 per cent	lb.	40 —	50
Potassium chlorate, crystals	lb.	38 —	40
Potassium cyanide, 98-99 per cent	lb.	Nominal	
Potassium iodide	lb.	3 25 —	3 80
Potassium muriate 80-85 per cent. basis of 80 per cent	ton	325 00 —	350 00
Potassium nitrate	lb.	22 —	31
Potassium permanganate U. S. P.	lb.	3 65 —	3 75
Potassium prussiate, red	lb.	2 80 —	2 90
Potassium prussiate, yellow	lb.	1 15 —	1 20
Potassium sulphate, 90–95 p. c. basis 90 p. c.	ton	Nominal	
Rochelle salts	lb.	43 —	44
Salammoniac, gray gran.	lb.	18 —	19
Salammoniac, white gran.	lb.	17½ —	18
Sal soda	100 lb.	1 35 —	1 40
Salt cake	ton	22 50 —	25 00
Silver cyanide, based on market price of silver	oz.	61½ —	62
Silver nitrate	oz.	2 10 —	2 20
Soda ash, 58 per cent., light, flat (bags)	100 lb.		

Soda ash, 58 per cent., dense, flat	100 lb.	3.75	—	3.85
Sodium acetate	lb.	.23	—	.24
Sodium bicarbonate, domestic	lb.	.02½	—	.03
Sodium bicarbonate, English	lb.			
Sodium bichromate	lb.	.23½	—	.24½
Sodium bisulphite, powd.	lb.	.05¾	—	.06
Sodium chlorate	lb.	.24	—	.25
Sodium cyanide	lb.	.38	—	.40
Sodium fluoride, commercial	lb.	.18	—	.19
Sodium hyposulphite	lb.	.02½	—	.02¾
Sodium molybdate, per lb. of Mo	lb.	2.50	—	
Sodium nitrate, 95 per cent	100 lb.	Nominal		
Sodium nitrite	lb.	.29	—	.32
Sodium peroxide	lb.	.48	—	.50
Sodium phosphate	lb.	.04	—	.05
Sodium prussiate, yellow	lb.	.68	—	.69
Sodium silicate, liquid (60 deg.)	lb.	Nominal		
Sodium sulphide, 30 per cent., crystals	lb.	.02½	—	.03
Sodium sulphide, 60 per cent., fused	lb.	.05¾	—	.06
Sodium sulphite	lb.	Nominal		
Strontium nitrate	lb.	.25	—	.35
Sulphur chloride, drums	lb.	.06	—	.06½
Sulphur dioxide, liquid, in cylinders	lb.	.15	—	.40
Sulphur, flowers, sublimed	100 lb.	4.05	—	4.60
Sulphur, roll	100 lb.	3.70	—	3.85
Sulphur, crude	ton	Nominal		
Tin bichloride, 50 deg	lb.	.23½	—	.24½
Tin oxide	lb.	.78	—	.80
Zinc carbonate	lb.	.25	—	.30
Zinc chloride	lb.	.12½	—	.13
Zinc cyanide	lb.	Nominal		
Zinc dust, 350 mesh	lb.	.14	—	.16
Zinc oxide, American process XX	lb.	.12½	—	.14
Zinc sulphate	lb.	.05	—	.06

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.27	—	.30
Benzol, 90 per cent	gal.			
Toluol, in tank cars	gal.	(Fixed Price)		1.50
Toluol, for non-military use, in drums	gal.	(Fixed Price)		1.55
Xylol, pure, water white	gal.	.35	—	.50
Solvent naphtha, water white	gal.	.17	—	.22
Solvent naphtha, crude, heavy	gal.	.13	—	.16
Creosote oil, 25 per cent	gal.	.33	—	.35
Dip oil, 20 per cent	gal.	.29	—	.30
Pitch, various grades	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05	—	1.10
Carbolic acid, crude, 50 per cent	lb.	.60	—	.65
Carbolic acid, crude, 25 per cent	lb.	.35	—	.38
Cresol, U. S. P.	lb.	.18	—	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00	—	1.25
Alpha naphthol, distilled	lb.	1.60	—	2.00
Alpha naphthylamine	lb.	.58	—	.60
Aniline oil, drums extra	lb.	.25½	—	.27
Aniline salts	lb.	.32	—	.34
Anthracene, 80 per cent	lb.	.50	—	.65
Benzaldehyde (f.l.c.)	lb.	5.50	—	6.00
Benzidine, base	lb.	1.75	—	1.85
Benzidine, sulphate	lb.	1.40	—	1.50
Benzoic acid U. S. P.	lb.	3.75	—	3.90
Benzoate of Soda, U. S. P.	lb.	3.30	—	3.40
Benzyl chloride	lb.	2.25	—	2.75
Beta naphthol benzoate	lb.	10.00	—	12.00
Beta naphthol, sublimed	lb.	.85	—	.90
Beta naphthylamine, sublimed	lb.	2.65	—	
Dichlor benzol	lb.	.12	—	.18
Diethylaniline	lb.	4.50	—	5.00
Dinitro benzol	lb.	.35	—	.40
Dinitrochlorbenzol	lb.	.40	—	.42
Dinitronaphthaline	lb.	.55	—	.60
Dinitrotoluol	lb.	.55	—	.60
Dinitropbenol	lb.	.46	—	.50
Dimethylaniline	lb.	.70	—	.72
Diphenylamine	lb.	1.00	—	1.10
H-acid	lb.	2.25	—	2.50
Metaphenylenediamine	lb.	2.00	—	2.25
Monochlorbenzol	lb.	.17	—	.19
Naphthalene, flake	lb.	.09½	—	.09¾
Naphthalene, balls	lb.	.10¾	—	.10¾
Naphthionic acid, crude	lb.	1.20	—	1.30
Naphthylamin-di-sulphonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.45	—	.50
Nitro toluol	lb.	.50	—	.55
Ortho-amidophenol	lb.			
Ortho-dichlor-benzol	lb.	.15	—	.18
Ortho-toluidine	lb.	1.00	—	1.25
Ortho-nitro-toluol	lb.	.75	—	1.00
Para-amidopbenol, base	lb.	3.50	—	3.75
Para-amido-phenol, H. Ch.	lb.	4.00	—	5.00
Para-dichlor-benzol	lb.	.12	—	.15
Paranitraniline	lb.	1.50	—	1.55
Para-nitro-toluol	lb.	1.50	—	1.60
Paraphenylenediamine (base)	lb.	3.00	—	3.25
Para toluidine	lb.	2.25	—	2.50
Phthalic acid anhydride	lb.	3.50	—	4.00
Phenol, U. S. P.	lb.	.48	—	.49
Resorcin, technical	lb.	5.75	—	6.00
Resorcin, pure	lb.	8.50	—	9.00
Salicylic acid	lb.	.88	—	.90
Salol	lb.	1.90	—	2.00
Sulphanilic acid, crude	lb.	.30	—	.32
Tolidin	lb.	2.50	—	
Toluidine-mixture	lb.	.75	—	.85

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4.00	—	....
Corning, Ohio	bbl.	2.85	—	....
Somerset, Ky	bbl.	2.60	—	....
Wooster, Ohio	bbl.	2.58	—	....
Indiana	bbl.	2.18	—	....
Illinois	bbl.	2.32	—	....
Oklahoma and Kansas	bbl.	2.25	—	....
Caddo, La., light	bbl.	2.25	—	....
Corsicana, Tex., light	bbl.	2.35	—	....
California	bbl.	1.23	—	....
Gulf Coast	bbl.	1.35	—	....

Fuel Oil

New York	gal.	.11	—	....
Pittsburgh	gal.	.07½	—	.10
Oklahoma-Kans	bbl.	1.05	—	2.75
Texas	bbl.	1.50	—	1.90
Los Angeles	bbl.	1.60	—	....
San Francisco	bbl.	1.60	—	....

Gasoline (Wholesale)

New York	gal.	.24	—	....
Boston	gal.	.25	—	....
Pittsburgh	gal.	.28	—	....
Chicago	gal.	.22½	—	....
Oklahoma	gal.	.25	—	....
San Francisco	gal.	.20	—	....

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.21	—	.22
Cylinder, light	gal.	.36	—	.38
Cylinder, dark	gal.	.35	—	.36
Paraffine, high viscosity	gal.	.40	—	.41
Paraffine, .903 sp. gr.	gal.	.36	—	.38
Paraffine, .885 sp. gr.	gal.	.26	—	.28

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	.44	—	....
Pine oil, steam-distilled, sp. gr. 0.925-0.940	gal.	.53	—	....
Pine oil, destructively distilled	gal.	.49	—	....
Pine-tar oil, sp. gr., 1.025-1.035	gal.	.35	—	....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.40	—	....
Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f. o. b. works	gal.	.34	—	....
Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f. o. b. works	gal.	.25	—	....
Pine-tar oil, ref., thin, sp. gr. 1.060-1.080	gal.	.32	—	....
Turpentine, crude, sp. gr. 0.870-0.900	gal.	.40	—	....
Hardwood oil, f. o. b. Michigan, sp. gr. 0.960-0.990	gal.	.19	—	....
Hardwood oil, f. o. b. Michigan, sp. gr. 1.06-1.08	gal.	.19	—	....
Wood creosote, ref. f. o. b. Florida	gal.	.31	—	....

Vegetable and Other Oils

China wood oil	lb.	.26	—	.27
Cottonseed oil, crude	lb.	.21	—	.22
Linseed oil, raw, cars	gal.	1.57	—	1.59
Peanut oil, crude	gal.	1.35	—	1.36
Rosin oil, first run	gal.	.41	—	....
Rosin oil, fourth run	gal.	.58	—	....
Soya bean oil, Manchuria	lb.	.16¾	—	.16½
Turpentine, spirits	gal.	.51	—	.51½

Miscellaneous Materials

Barytes, floated, white, foreign	ton	Nominal		
Barytes, floated, white, domestic	ton	32.00	—	36.00
Beeswax, white, pure	lb.	.62	—	.64
Casein	lb.	.14¾	—	.18
Chalk, light, precipitated, English	lb.	Nominal		
China clay, imported, lump	ton	17.50	—	36.00
China clay, domestic, lump	ton	12.50	—	20.00
Feldspar	ton	8.00	—	12.00
Fluorspar, gravel, f. o. b. mines	ton	30.00	—	....
Fuller's earth, powdered	100 lb.	1.00	—	1.50
Graphite, flake	lb.	.15	—	.18
Ozokerite, crude, brown	lb.	Nominal		
Ozokerite, American, refined, white	lb.	Nominal		
Red lead, dry, carloads	lb.	.10	—	.11¾
Rosin, 280 lb.	bbl.	7.50	—	....
Soapstone	ton	10.00	—	12.50
Talc, American, white	ton	15.00	—	22.00
White lead, dry	lb.	.09	—	.10

Refractories, Etc.

(F. O. B. Works)

Chrome brick	net ton	75.00	—	....
Chrome cement	net ton	75.00	—	....
Clay brick, 1st quality fireclay	per 1000	50.00	—	55.00
Clay brick, second quality	per 1000	35.00	—	40.00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined, powdered	ton	32.00	—	35.00
Magnesite, dead burned	net ton	50.00	—	60.00
Magnesia brick, 9x4½x2½	net ton	110.00	—	125.00
Silica brick	per 1000	50.00	—	60.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent., carloads, f. o. b. Niagara Falls, N. Y.	ton	....	—	....
Ferrocerium	lb.	3.00	—	....
Ferrochromium, per lb. of Cr	lb.	....	—	....
Ferromanganese, domestic, 70 per cent. basis	ton	250.00	—	....
Ferromanganese, English	ton	325.00	—	....
Ferromolybdenum, per lb. of Mo	lb.	5.00	—	....
Ferrosilicon, 75 per cent., f. o. b., N. Y.	ton			
Ferrosilicon, 50 per cent., carloads, del., Pittsburgh	ton	180.00	—	190.00
Ferrosilicon, 50 per cent., contract	ton	160.00	—	170.00
Ferrotungsten, 75-85 per cent., f. o. b., Pittsburgh	lb.	2.35	—	2.40
Ferrouranium, f. o. b. works, per lb. of U	lb.	7.50	—	....
Ferrovanadium, f. o. b. works	lb.	....	—	....

Ores and Semi-finished Products

Antimony ore, per unit		....	—	....
Chrome ore, 45 per cent. minimum, f.o.b. Cal., per unit	ton	1.50	—	1.55
Chrome ore, 43 per cent. and over, New York, per unit	ton	....	—	....
Manganese ore, 48 per cent. and over, per unit	ton	1.20	—	....
Manganese ore, chemical	ton	80.00	—	100.00
Molybdenite, per lb. of MoS_2	lb.	1.25	—	....
Tungsten, Scheelite, per unit of WO_3	ton	24.00	—	....
Tungsten, Wolframite, per unit of WO_3	ton	24.00	—	....
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	....
Pyrites, foreign	unit	.17	—	.17½
Pyrites' domestic	unit	.28	—	.30

INDUSTRIAL NEWS

Plant Construction—Catalogs—New Publications

Construction and Operation

Arizona

TUCSON.—The Pima Mining & Smelting Co. plans to enlarge the capacity of its smelter plant from 250 tons to 500 tons daily. William Kemp is manager.

California

GRASS VALLEY.—The Grass Valley Consolidated Gold Mines Co. is building a shaft, mill and cyanide plant. Estimated cost, $225,000.

OATMAN.—The Mossback Mines, at Line Road section of Gold Road property, plans to install a new crushing plant. About half a dozen buildings will be put up, powerful plant installed and main shaft sunk from present depth of 300 ft. to 500 or 600 ft.

Connecticut

BRIDGEPORT.—Whipple & Choate Co., Iranistan Ave., has awarded the contract for the construction of a 1-story, 27 x 27 ft., mill construction addition to its foundry, to H. D. Moon, 208 Stratford Rd. and T. O'Brien, 137 Black Road Ave.

HARTFORD.—The Hartford Rubber Co., Park St., has awarded the contract for the construction of a 1½-story, 50 x 150 ft., concrete, brick and steel factory on Bartholomew Ave., to S. H. Grozier Co., 721 Main St. Estimated cost, $14,000.

HARTFORD.—The Maxim Silencer Co., 81 Homestead Ave., has awarded the contract for the construction of a 1½-story, 30 x 300 ft. factory to be used for the manufacture of attachments for guns, to the Ellison Construction Co., 60 Prospect St. Estimated cost, $20,000.

WATERBURY.—The Waterbury Clock Co., 31 Cherry Ave., plans to build a large manufacturing building.

Idaho

WALLACE.—The Friend Mining Co., will install a mill consisting of crusher, ball mill, flotation machine and concentrating table.

Illinois

CHICAGO.—The Cross Press & Sign Co., c/o C. E. Frazier, 30 North Dearborn St., plans to build a 1- and 2-story, 75 x 75 ft., reinforced concrete tannery at Dayton and Black Hawk Sts. Estimated cost, $15,000.

CHICAGO.—B. Heller & Co., 3925 Calumet Ave., manufacturer of edible chemicals, plans to build a 2-story, 125 x 250 ft. brick addition to factory. J. C. Llewellyn, 38 South Dearborn St., is engineer.

CHICAGO.—The International Harvester Corporation, Chicago, has awarded the contract for the construction of a grey iron foundry, to McClintic Marshall Co., 38 South Dearborn St.

CHICAGO.—The Western Dry Color Co., 608 West 52nd St., will build a 2-story brick factory. Estimated cost, $5000.

CICERO.—The General Malleable Co., South 55th Court and West 14th St., will build a 1-story, 132 x 222 ft. brick factory and warehouse at South 55th Court and West 13th St. Estimated cost, $18,000.

GRANITE CITY.—The Commonwealth Steel Co., Pierce Building, St. Louis, Mo., will build a 1- and 2-story addition to its plant. Estimated cost, $500,000.

KANKAKEE.—The American Truck & Aeroplane Co. has purchased the plant of the Unifle Co. at Riverview Ill. and will equip same for the manufacture of automobile motor trucks and airplanes.

Indiana

ANDERSON.—The Hill Pump Co. has awarded the contract for the construction of a 100 x 200 ft., brick and steel foundry at the south end of its plant, to the Builders Construction Co., Indianapolis. Estimated cost, $45,000.

GARY.—The Illinois Steel Co., 208 South La Salle St., Chicago, Ill., has awarded the contract for the construction of two 141,000 gallon sulphuric acid tanks at its plant here to the American Bridge Co., 208 South La Salle St., Chicago.

GARY POST.—The Gary Motor Truck Co., 610 Broadway plans to build a large addition to its plant.

SOUTH BEND.—The Malleable Steel Range Co., Cherry St. and Jefferson Blvd., plans to build a 2-story 34 x 88 ft. brick and steel factory building. Estimated cost, $10,000.

TERRE HAUTE.—An addition will be built to the machine shop at the Gott Glass Co. Johnson & Miller, 105 South Seventh St. is the architect.

WABASH.—The Service Motor Truck Co. will build a 1-story, 75 x 200 and 75 x 150 ft. factory. Nicol & Dietz, 212 Murdock Building, La Fayette, architects.

DES MOINES.—The Green Foundry & Furnace Works, 100-10 South West 2nd St., plans to build a 106 x 110 ft. brick and steel foundry. Frank D. Chase, Inc., 122 South Michigan Ave., Chicago, Ill. is engineer.

Iowa

FORT MADISON.—The Karamoid Manufacturing Co. will build a 2-story, 60 x 200 ft., brick, pulp container factory here by day labor. F. J. Klein, 127 South Jefferson St., architect, will supervise construction.

SIOUX CITY.—The Sioux City Tire & Manufacturing Co. plans to construct several new additions to its plant.

STORM LAKE.—The International Chemical Co. will build a factory at Lakeside Farm, a mile from the city, for the manufacture of phenol to be used by the Government in the manufacture of explosives.

Kansas

BAXTER SPRINGS.—C. M. Mitchell, E. D. Nix and L. H. Knight will build 75 ton concentrating mill at mine here to include crushers, slime tables, engines and boilers. Estimated cost, $50,000.

Massachusetts

CAMBRIDGE.—Harvard University will build a biophysical laboratory on Huntington Ave. Estimated cost $60,000. Coolidge & Shattuck, Ames Building, Boston, architects.

NORTHAMPTON.—The Trustees of Smith College, College Hall, have awarded the contract for the construction of a brick addition to the chemistry building, to Allen Bros., 125 South Pleasant St., Amherst.

WORCESTER.—The Worcester Stamped Metal Co., 9 Hunt St., has awarded the contract for the construction of a 1-story brick addition to its plant, to E. J. Cross Co., 82 Foster St. Estimated cost $10,000.

Michigan

DETROIT.—The Ford Motor Co. Highland Park will build an addition to its plant consisting of 16 shops, 18 x 260 ft. The new plant will be used for the assembly and testing of the Liberty Motor.

DETROIT.—The McCord Manufacturing Co., Grand Boulevard and Orleans St., has awarded the contract for the construction of a 1- and 3-story 161 x 372 ft. reinforced concrete munition factory to Pleas Construction Co., 30 North La Salle St., Chicago, Ill. Estimated cost $70,000.

Minnesota

ST. PAUL.—The American Hoist & Derrick Co., Water and Roberts Sts., has awarded the contract for the construction of a 1-story 20 x 40 x 74 ft. brick and steel machine shop, to G. J. Grant Construction Co., Exchange Bank Building. Estimated cost $19,270.

Missouri

PLEASANT HILL.—City let contract for sewage disposal plant to Lange & McDonald Construction Co., Moberly.

SENECA.—The Oklahoma Motor Co. plans to install stone tables, rock crusher, engines and boilers in its mine here. Estimated cost $75,000. C. T. Jobes, is architect in charge.

ST. JOSEPH.—The Berry Iron & Steel Co., 5th and Oak Sts. has awarded the contract for the construction of a new [illegible] to replace the one destroyed by fire. The Lehr Construction Co., 1712 Fred Ave., will erect five buildings for storage, and one for the office of concrete, brick and steel construction.

WEST PLAINS.—The Missouri Iron & Steel Corporation plans to build a smelting plant here. The construction of the company's ore in Howell County has yet to be extended [illegible] operations in North Arkansas and South Missouri. Estimated cost $6,000,000.

Montana

POLARIS.—The Silver Figure Mining Co. will build a mill roasting and hydrosulphide plant here.

Nebraska

PLATTSMOUTH.—The Auto Power & Malleable Co. has taken over the plant and business of the Western Machine Foundry Co. and will build a new and larger plant. Estimated cost, $250,000.

New Jersey

HOBOKEN.—W. & A. Fletcher Co., 1204 Hudson St., has awarded the contract for the construction of a 3-story, 50 x 145 ft. brick factory for the manufacture of marine engines, etc., to William Crawford, 7 East 42nd St., New York City. Estimated cost, $50,000.

HOBOKEN.—The Remington Arms Co.-Union Metallic Cartridge Co., 1540 Hudson St., has awarded the contract for the construction of a 1-story, 81 x 160 ft., reinforced concrete, brick and steel factory to Austin Co., 16112 Euclid Ave., Cleveland, O. Estimated cost $100,000.

JERSEY CITY.—The Vulcan Iron Works, Morris St., plans to build two 1-story, 60 x 100 ft., brick and steel additions to its plant on Hudson St. Estimated cost, $50,000.

MILLVILLE.—The International Glass Co. has awarded the contract for the construction of a 1-story, 60 x 104 ft., concrete, brick and steel glass factory here to Austin Co., 16112 Euclid Ave., Cleveland, O. Estimated cost, $35,000.

NEWARK.—C. A. Goldsmith, Ave. D and Thomas St., will build a 1-story, 50 x 150 ft., brick brass foundry. Estimated cost, $24,000.

NEWARK.—The Holophane Glass Co., east side of Oakwood Ave. near the Pennsylvania Railroad tracks, will build a 50 x 75 ft. tank shop. Capacity two and one-half tons of molten glass.

TRENTON.—The Trenton Malleable Iron Co., New York Ave., has awarded the contract for the construction of a 1-story, 44 x 146 ft., concrete, brick and steel foundry addition, to N. A. Bugbee Co., 241 West State St. Estimated cost $10,000.

New York

BUFFALO.—The Acme Steel & Malleable Iron Works, 120 Chandler St., has awarded the contract for the construction of a 1-story, 100 x 175 ft. brick and steel iron plant, to J. W. Cowpers Co., Fidelity Building. Estimated cost $25,000.

BUFFALO.—The Ferguson Steel & Iron Co., 1399 Valley Ave., has awarded the contract for the construction of a 1-story, 400 x 800 ft., concrete, brick and steel shipbuilding plant to J. W. Cowpers Co., Fidelity Building. Estimated cost $100,000.

BROOKLYN.—The Decorated Metal Co., 196 Degraw St., has awarded the contract for altering the tenement at 192 Degraw St. into a factory for its own use, also building 1-story addition to H. D. Best Co., 52 Vanderbilt Ave., New York City. Estimated cost, $20,000.

BROOKLYN.—The Improved Appliance Co., manufacturer of gas appliances, 455 Kent Ave., plans to build a 1-story, 67 x 97 ft., reinforced concrete, brick and timber factory. Estimated cost $15,000.

LONG ISLAND CITY.—The John Palcoreck Bronze & Iron Co., 48 Hancock St., will build a 1-story, 75 x 100 ft. concrete and brick foundry. H. Hutton, architect. Estimated cost $15,000.

LONG ISLAND CITY.—The [illegible] Sterling & Packing Co., 35-37 Eider Ave., has awarded the contract for the construction of 11 [illegible] 75 x 150 ft. [illegible] roof, to McGraw Construction Co., 1178 Broadway, New York City. Estimated cost $[illegible].

LONG ISLAND CITY.—The [illegible] Iron & Steel Co., 43 Hancock St., has awarded the contract for a 1-story, 75 x 150 ft. [illegible] foundry. Estimated cost $[illegible].

MASSETH.—The Dexter Steel & Forging Co. will build a 1-story, [illegible] Creek St. 75 ft. [illegible] Estimated cost $[illegible].

NEW YORK.—The Yale [illegible] Co., [illegible] 1-story [illegible] Estimated cost $[illegible].

[illegible] Bros. Co., [illegible] Estimated cost $[illegible].

[illegible] Co., [illegible] Estimated cost $[illegible].

[illegible] Co., [illegible] Estimated cost $[illegible].

[illegible]

ROCHESTER.—The High Speed Hammer Co., Norton St., will build a plant consisting of two buildings, at Clinton Ave., N., and Hellenbeck St., one to be 1-story, 53 x 101 ft. and another 2-story, 18 x 53 ft. Estimated cost, $40,000.

Ohio

CANTON.—The Timken Roller Bearing Co., Dueber Ave., will build a steel manufacturing building. Estimated cost, $180,000. The company recently obtained a large order from the Government for automobile machinery.

CINCINNATI.—The Cincinnati Gear Co., 1825 Reading Road, will build a 1-story, concrete and brick addition to its factory. Estimated cost, $24,000.

CINCINNATI.—The City will build a new asphalt plant on Florence Ave., to replace the one destroyed by fire, entailing a loss of $20,000.

CINCINNATI.—(Norwood) The George B. Curd Co. has purchased the factory on Highland Ave. formerly occupied by the Niebling Ice Machine Co. and will remodel same for its own use as a locomotive repair shop.

CINCINNATI.—The John H. McGowan Co., 52 Central Ave., will remodel, also build an addition, to its machine plant. Estimated cost, $10,000.

CINCINNATI.—The John B. Morris Foundry Co., Court and Harriet Sts., will improve its plant. Estimated cost, $10,000.

CINCINNATI.—(Oakley) The Trailmobile Co. manufacturer of automobile trailers, will build a manufacturing building to contain 80,000 sq ft. floor space. Estimated cost, $300,000. E. M. Chase, Union Centre Building, is engineer.

CLEVELAND.—The Crucible Steel Forge Co., Grant Ave., plans to build a 1-story shop addition. Estimated cost, $30,000.

CLEVELAND.—The Damascus Manufacturing Co., manufacturer of oil specialties, East 93rd and Cassius Sts., has awarded the contract for the construction of a 2-story, 30 x 50 and 80 x 105 ft., concrete, brick and steel factory addition, to J. H. Chaney & Son Co., 563 Hippodrome Annex. Estimated cost, $30,000.

CLEVELAND.—The Templin-Crockett-Bradley Co., 5700 Detroit Ave., has awarded the contract for the construction of an addition to its plant, to F. A. Skeel, 3719 Cypress Ave. Estimated cost, $30,000.

CLEVELAND.—The Wilberite Roofing Co., Brook Park and State Roads, is building a new factory here. Estimated cost, $22,000.

CLEVELAND.—The Willard Storage Battery Co., 274 East 131st St., plans to build a concrete, brick and steel factory and office building. Estimated cost, $150,000.

COLUMBUS.—The Atlas Brass Foundry Co., Stewart Ave. and Park St., S., has awarded the contract for the construction of a new factory addition, to Nonnemacher & Frank, East Gates St. Estimated cost, $8000.

COLUMBUS.—The Columbus Rendering Co., Frank Road and Jackson Pike, has awarded the contract for the construction of a 2-story, 32 x 72 ft. brick rendering plant, to E. Elford, Commercial Building. Estimated cost, $15,000.

DAYTON.—The Advance Foundry Co., Harshman and Crane Sts., plans to build a new grey iron foundry on Parnell Ave., near the Pennsylvania R.R. Estimated cost, $200,000.

EUCLID.—The Euclid Chemical Co., c/o R. L. Beck, 311 The Arcade, Cleveland, will build a 3-story, reinforced concrete, brick and steel factory. Estimated cost, $50,000.

HAMILTON.—The Black & Clawson Co., 2nd and Vine Sts., builder of paper-making machinery, has awarded the contract for the construction of a 1-story, 60 x 80 ft., brick and steel addition to its foundry, to Bert L. Baldwin Co., 502 Second National Bank Building, Cincinnati

LONDON.—The London Fabrics Mill Co., recently incorporated, will build a 60 x 70 ft. brick and steel factory for the manufacture of fabrics to go into rubber tires.

NORWOOD.—The A. V Carroll Machine Tool Co., Highland Ave., has awarded the contract for the construction of a new plant, to F. E. Ratcliff, Batavia. Estimated cost, $10,000.

NORWOOD.—The Warman Aluminum Castings Co., 1741 Central St., Cincinnati, has leased a building at Main and Lexington Aves. and will equip same for the manufacture of aluminium castings.

SANDUSKY.—The Farrell Cheekseel Foundry, foot of 1st St., will build an addition to its plant.

SANDUSKY.—The Vim Motor Co., Water and Meigs Sts., has awarded the contract for the construction of a 100 x 180 ft. addition to its plant, to A. S Schnurr, 1003 West Jefferson St.

TOLEDO.—The Bunting Brass & Bronze Co., Spencer and Carlton Sts., will build a 2-story, 120 x 175 ft., brick, cement and steel brass foundry. Estimated cost, $150,000. Mills, Rhines, Bellman & Nordhoff, 1234 Ohio Building, architects.

TOLEDO.—The Royster Guano Co., 813 Second National Bank Building, will build a fertilizer plant on Stickney Ave. Estimated cost, $35,000.

TOLEDO.—The Toledo Tap & Die Co., Clinton St., plans to build a 1-story, 50 x 200 ft., concrete, brick and steel factory, for the manufacture of machine tools, taps and dies. Estimated cost, $20,000.

WARREN.—The A. B. Smith Chemical Co., Red House, will build a new plant to replace the one destroyed by fire with a loss of $150,000.

Oklahoma

BARTLESVILLE.—The Bureau of Mines plans to build a 2-story, 42 x 102 ft. laboratory of brick construction. Keene & Simpson, 400 Reliance Building, architects. Estimated cost, $30,000.

GUTHRIE.—The Empire Oil & Gas Co. plans to build a second oil refinery here.

MIAMI.—The Lightfoot Oil & Mining Co. will build a 100 ton concentrating mill to include slime tables, crushers, engines, boilers and air machines. Estimated cost, $100,000. H. Holman, is vice president.

MIAMI.—The Mint Mining Co. will build two 75 ton concentrating mills to include slime tables, crushers, boilers and engines. Estimated cost, $100,000. Julius Labsap is superintendent.

Pennsylvania

FORD CITY.—The Fawcus Machine Co. plans to build a 50 x 100 ft. addition to its plant here. The Company recently obtained several large Government orders which make this addition necessary.

MORRISTOWN.—The Conshohocken Iron & Steel Co. plans to build a modern ore crushing mill, for crushing chrome ore, which is used in steel making, furnace lining and other work.

PHILADELPHIA.—The Aetna Foundry Co., 22nd St. and Allegheny Ave., has awarded the contract for the construction of a 1-story, 50 x 70 and 20 x 50 ft., brick foundry, to A. Raymond Raff, 17th and Thompson Sts. Estimated cost, $10,000.

PHILADELPHIA.—The Cresson & Morris Co. has awarded the contract for the construction of a 50 x 100 ft. foundry at 18th St. and Allegheny Ave., to the Raith Construction Co., 302 West Master St.

PHILADELPHIA.—Morris Wheeler & Co. has awarded the contract for the construction of a 467 x 616 x 325 ft. fabricating steel shop, fireproof, to William Steele & Sons, 308 South 15th St. Estimated cost $500,000.

PHILADELPHIA.—The United States Government will build a 1-story, 57 x 154 ft., brick and reinforced concrete, aircraft factory at League Island. Estimated cost, $20,000. W. Deiley, 1616 Thompson St., is architect.

PITTSBURGH.—The C. R. Moore Co., Arrott Tower Building, plans to build a 1-story, concrete, brick and steel printing house on West Liberty Ave., Nineteenth Ward. Estimated cost, $45,000.

Rhode Island

PAWTUCKET.—The Collyer Insulated Wire Co., 249 North Main St., will build a 3 story, 83 x 170 ft. brick manufacturing plant. Estimated cost, $80,000.

Tennessee

LYLES.—The United States Government has awarded the contract for the construction of a wood chemical plant, to George A. Fuller Construction Co., 175 5th Ave., New York City. Estimated cost, $1,300,000. The Bon Air Coal & Iron Corporation, Stahlman Building, Nashville, will operate the plant for the Government.

Texas

WACO.—W. McMahon, 802 Kipling St., plans to build a refinery at the South Bosque oil fields.

Utah

SALT LAKE.—The Lucky Star Copper Co. plans to build a small concentration plant at its mine in the Dugway District.

Virginia

SEVEN PINES.—The War Department, Washington, D. C., has awarded the contract for the construction of a powder packing plant here, to the Foundation Co., Woolworth Building, 233 Broadway, New York City. Estimated cost, $3,000,000. E. I. DuPont de Nemours & Co., Henry Clay St., Wilmington, Del., will operate the plant for the Government.

Washington

EVERETT.—Everett Lister plans to build a plant here for the manufacture of potash from wood ashes and later from kelp.

EVERETT.—The Everett Steel Co. will build a 75 x 100 ft., brick building on McDougall St. between Wall St. and Smith Ave. T. B. Sumner of Sumner Iron Works is president of new company.

SPOKANE.—The Armstead Mines will build a concentrating mill and purchase additional equipment. Estimated cost, $100,000. The first unit of the plant will have about 100 tons capacity.

West Virginia

FAIRMONT.—The Fairmont By-Products Co. will build a by-product coke oven plant. Initial capacity 110 tons ovens and ultimate 330. Estimated cost, $5,000,000.

SUTTON.—The Sutton Chemical Co. will build an addition to its plant here. Estimated cost, $200,000. The company recently obtained large contracts from the Government which makes this addition necessary.

Wisconsin

CARROLLVILLE.—The Newport Chemical Works, manufacturer of phenol products 1112 First National Bank Building, Milwaukee, will build an addition to its plant here.

EAU CLAIRE.—The United States Switch Co. plans to build additions to double the capacity of its foundry and install milling machines, turret lathes and a one-ton electric steel furnace. A complete drop forge unit also will be added.

MILWAUKEE.—The Universal Machinery Co., 784 30th St., manufacturer of lathes and other machine tools, plans to build a new foundry and machine shop at the foot of 64th Ave. Estimated cost, $250,000. Frank E. Gray, 86 Michigan St., is architect.

PLYMOUTH.—The National Milk Sugar Co., 16 Park Row, New York City, will build a 1-story and 2-story, 40 x 120 ft., brick and mill construction sugar refinery here. Estimated cost, $20,000.

WEST ALLIS.—The Universal Machinery Co., 784 30th St., will build a 150 x 250 ft. factory, 100 x 150 ft. foundry, and a 50 x 50 ft. power house. Estimated cost, $250,000. E. C. Devine is president.

Canada

ILLICILLEWAET, B. C.—The Lanark Mines Co. is installing hydro electric plant at its mine here. Estimated cost, $300,000.

Industrial News

The CLARAGE FAN COMPANY, Kalamazoo, Mich., announces the removal of their Chicago branch to Room 1666, Conway Building, 111 W. Washington Street, under the management of Gardner J. Thomas.

The INDUSTRIAL ELECTRIC FURNACE CO., of Chicago, makers of the Snyder furnace, have shipped a 1250-lb. capacity electric steel furnace, together with the auxiliary electrical equipment, to Burn & Co., Calcutta, India, the largest iron, steel and foundry company in India. The purchase of this Snyder furnace shows the progressive tendency toward modern equipment and modern practice in that field.

The ASBESTOS PROTECTED METAL COMPANY of Pittsburgh changed its name on May 1st to the Aspromet Company. When this company was established, in 1905, its sole product was asbestos protected metal. Their initial product meeting with favor resulted in their complementing the same by adding to their line other building materials used and bought by the same people who use and buy asbestos protected metal. Now they have a complete line of building material specialties, many of which contain neither asbestos nor metal in their make-up. Thus, the descriptive name, Asbestos Protected Metal Company, which originally served them so well, became restrictive to the point of being misleading; hence the change.

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Beginning to See Light

THERE were a number of gentlemen seated in discussion at the Crystalloid Club. That is not its corporate name, but the disposition of its Committee on Admissions to function as a permeable membrane against applicants for membership suggests the appellation. Among the company was one of the leaders of the New York bar. "There is a man," said he, "who calls at my office occasionally to collect money for a welfare organization, and I usually give him a little contribution, rather to get him to talk than for his cause. He travels all over the country and he is a very observant person. His comments are keen and I get more out of him than he gets out of me. The other day he was in a talking humor and I asked him how the people of the West or South feel about the war. 'You New Yorkers,' he answered, 'do not seem to appreciate how much alike the people of the country are: ours is the only nation in the world which is nowhere provincial. With the exception of certain colonies of foreigners that remain unAmericanized, the people of the United States are the same, not different. Whether I am here or in Buffalo or Chicago or Omaha or San Francisco or Galveston or New Orleans or Atlanta or anywhere else, the cities have a remarkable cousinship in appearance; the men are alike, each after his kind; they dress according to the same fashions and their habits of thought are very similar. Abstract ideas, unless they bear upon local conditions, are received in much the same temper all over the country. I do not mean to say that our cities or centers lack individuality, because Americans are too much alive to travel in herds or be dull, but they are nowhere provincial.

"'Take the news-stands, for example. Everywhere I find the same periodicals and in about the same proportions: the same little piles of literary magazines and reviews, the same larger piles of the cheaper ones, the higher stacks of the periodicals for women and the still higher ones of the *Saturday Evening Post*, with the usual proportion of Hearst's Lures of Sex for the Adolescent. The whole country reads the same literature, both good and bad, and discusses it. Now that is what holds us together: reading the same literature at the same time. It is what is backing up the country in the resolution to win the war. I take it that your friends are safe and loyal. Well, so are the friends of nearly anybody else, no matter where he lives, in the United States. Of course there are hot-beds of sedition and of German propaganda here and elsewhere, but they are getting about the same treatment in one place as in another. Think how little unity of interest there would be among our people if they thought only of their business; of what they produce! But they have

unity in literature, the literature of every day. These periodicals, which are so widely read, gather in sentiments from all over the country and spread them abroad. They make us laugh together and cry together. Where they are published is unimportant; it is the habit of writing in terms of the whole nation that makes them such great factors. And I really believe that if the zone system of postal rates is established, it will forbid national circulation, and there is serious danger that this will kill the very thing that has taken us so long to build up: the unity of the people. I cannot imagine a more insidious method than this to bring about provincialism and the envy and ill-will that is sure to follow it. It is a destructive attack upon the national community of mind.'

"I declare," continued the leader of the bar, "I believe the man was right." The others agreed with him and proceeded with unanimity to consider ways and means to combat the impending danger.

Furnace Slags in Theory and Practice

ONE sometimes resents the intrusion of the physico-chemical-minded metallurgist with his phase rule rudely unhorsing us from that simple hobby that our furnace slags are quasi-chemical compounds, and can be accurately termed singulo-, sesqui- or bi-silicates. Even before the advent of this scientific irritant, the hypothetical behavior of alumina was always a fly under the saddle blanket, and the pestiferous question as to whether it should be figured on the acidic or the basic side of the equation provoked reams upon reams of discussion. Fortunately the most of our furnaces worked calmly on, smelting high alumina and other unreasonable ores without waiting for the decision to be rendered, which probably will arrive the same day the disputants can find some definition of the terms "acid" and "base" which will apply at temperatures so far above the boiling point of aqueous solutions. At any rate, when furnace computation is sifted down to realities, do we not merely try to approximate some slag which experience has taught will be suitable?

Thus we sidestep the fundamental questions which the equilibrium diagram solves, and which chemical analysis alone is as incapable of solving as it was the age-old mystery of hardened steel. The researches of the scientists at the Geophysical Laboratory have blazed the way for a rational interpretation of the chemistry of silicates, and have proved, for instance, that in the ideal case of lime-silica slags only four chemical compounds exist in all possible compositions, from pure silica to pure lime, namely SiO_2, $CaSiO_3$, Ca_2SiO_4 and CaO. In such a series sub-silicates, sesqui-silicates, and tri-silicates simply have no objective existence. Again, the iron blast-furnace with its additional aluminous burden produces slags in which the stable entities are gehlenite and calcium metasilicate.

However, the laboratory metallurgist should not fail to visit his brothers in the cast-house regularly and often, going with the attitude of a student seeking information rather than that of an instructor dispensing wisdom. Else he will probably work a long time before he discovers that the furnace man consistently avoids the use of the slag composition which has the lowest melting point, primarily because it is so viscous that it cannot be handled. On the other hand, the furnace man believes (and he may very likely be right in his belief) that one of his biggest jobs is to get all the lime, magnesia, alumina and silica charged at the top to come out at the bottom, be it as $CaSiO_3$, Ca_2SiO_4, or what not. He likes to formulate some simple rule easy to work by (and who can blame him), such as "the higher the lime the more sulphur will go to the slag," bolstering it up with a nice reaction between calcium oxide and iron sulphide which balances neatly and looks good. But it isn't elastic enough to stretch over all the facts! In his dilemma, the works metallurgist, if he is friendly to the laboratory metallurgist, can get information to the effect that his rule is wrong simply because calcium oxide as such has not appeared in any furnace slag since the invention of the cinder notch, *except*—and here even the wise physico-chemico-metallurgist will have to venture on another voyage of discovery—except for the possibility that the silicates formed in the topmost part of the smelting zone may dissociate into chemically active entities under the intense heat of the focus.

Really, that is the fun of it! There is always something left to look into, always the unexplained to be explained!

Recognizing the Metallurgical Engineer

AT the last meeting of the Board of Directors of the American Institute of Mining Engineers the sentiment was formally expressed that a change in name of the organization would be desirable in recognition of that element of the membership concerned primarily with metallurgy as distinct from mining.

The proposal is not new, but the action of the Directors of the Institute is the first step toward crystalizing an opinion that has been held and frequently expressed by many. A census of Institute members would show but one-third primarily interested in and devoting their energies to metallurgy. On the other hand a classification of Institute technical literature would disclose a predominance of papers devoted to metallurgy. All this is by way of logical evolution from the time when the duties of the mining man were not only to dig the ore out of the ground, but to operate a stamp-mill or smelting-cupola as well. With the exploitation of low-grade ores and new ones not known or needed in the earlier state of the art, came the demand for expert advice in ore treatment; and with the later developments in the production and uses of ferrous and non-ferrous metals and alloys, a new phase of metallurgy developed which is growing in significance.

At the present time there is a bid for metallurgical allegiance to several organizations. There is the Iron and Steel Institute, which had some excellent technical papers on the program at its recent meeting in New York. The impression prevails, however, that this association is engrossed with the purely business aspects of the industry. To a metallurgist, the American Foundrymen's Association is more like a trade organization, from which the American Institute of Metals branched several years ago; but even the latter deemed it advisable to join the A. I. M. E. in a body, forming the Institute of Metals division. In addition

to these there are the Mining and Metallurgical Society of America, which functions most actively in New York City; the American Electrochemical Society, which comprises an eminent body of engineers skilled in electrometallurgy; the Steel Treating Research Society, comprising an important and growing class of men who supervise the toolmaking and control the quality of the product of progressive metallic-manufacturing establishments; and the American Chemical Society, which has proposed the formation of a metallurgical section on the score that metallurgy is chemistry applied to the treatment of ores and metals. This Society is now the largest in its field, having grown rapidly in the last few years. It has rendered excellent service in mobilizing the American chemists for war, and all members of the profession should rally to its ranks. It may lay claim to the allegiance of metallurgists, but in our judgment the rapidly expanding field of industrial chemistry offers a greater opportunity for predominance by this important organization.

Evidently there is need of concentration of effort and interest. We are fully alive to the difficulties in the way of inducing societies, once organized, to lose their identity by merging into a large central body. There will always be organizations, numerically small but professionally important, devoted to highly specialized phases of the metallurgical industry. Nevertheless, under the present circumstances we incline toward the idea of making an "American Institute of Mining and Metallurgical Engineers" the great representative body of American metallurgists. The action of the Institute of Metals has pointed the way, and we hope the prospect will be bright enough to attract iron and steel metallurgists who may have felt no interest in a society of mining engineers. With the change in name they can feel perfectly at home, can have their special meetings and aid in promoting the solidarity of the profession.

All Steel for War

A YEAR ago, when technically we had been at war for two months, estimates ranging from 15 to 30 per cent were being made as to the proportion of the country's steel output the Government could use for waging war. Now the Government is requiring that all the steel be diverted to war use.

There is a wide difference between the estimates and the realization, and the divergence is emphasized by the fact that the authorities at Washington intimate that if the steel industry could produce still more steel that extra amount would not constitute a "surplus" for general distribution, because Washington would find a use for it also.

Why this great divergence? The arts of war have not changed in a twelvemonth, nor did those who made the 15 to 30 per cent estimates have incorrect appraisals of the amount of steel a single ship or shell or gun would use. It was their viewpoint as to the participation of the United States in the war that was incorrect. The Government had declared the state of war and "the people" were going to "support" the Government in some intangible way—give the Government its countenance and sympathy.

The condition to-day, however, is that every man, woman and child in the United States is, or should be, helping in one way or another to conduct the work of war. With such a condition obtaining it is a relatively simple matter for the war to absorb all the steel. The machinery and labor that ordinarily fits the products of the steel mill for actual useful employment is being utilized or will be utilized to fit the steel for war use and the labor that ordinarily uses these finished products will now use them in waging war.

The railroads, which for decades have been the best single customer of the iron and steel industry, have been made a government agency to aid in the prosecution of war. All steel used by the railroads is war steel. The building industry, normally a large consumer of steel, has been mobilized for war. The structural shops, instead of producing fabricated steel for bridges and buildings, are turning out parts for fabricated ships and fabricated material for innumerable storage warehouses on both sides the Atlantic. The automobile industry will build many tens of thousands of army trucks and many thousands of passenger cars for the army. Agriculture, normally a peace industry, is now a war industry and requires steel just the same. The production of fuel has become a war industry, and it will consume more steel rather than less, in the coal mine and in oil and natural gas development and transport. The production of many minerals is to be stimulated as a war development. The building of ordinary dwelling houses, to meet individual desires of the people, stops of its own accord by reason of high costs of material and scarcity of labor, but when population migrates in order to engage in war work new housing facilities must frequently be provided, and that involves a considerable amount of dwelling house construction, strictly a war necessity.

This glance at what is occurring industrially suggests the viewpoint that the war has not absorbed the steel directly, it has absorbed the machinery, the implements, the men that normally handle, fabricate and consume the steel. If the war were absorbing only one-fourth the steel output as was at one time expected, who is there to use the other three-fourths? The difference between the forecast and the realization is due simply to the much greater measure of control the war has taken of the entire people.

Thus the picture that is sometimes sought to be drawn, particularly in the daily press, of how industries are to be deprived of steel, becomes a very vague and shadowy one. In general, they are not deprived of steel to any greater extent than they are deprived of the opportunity to work with it, if they received it for ordinary uses, and sell the manufactured products that would result. The dislocation, or to use a word with a much better ring, the alteration, is not simply in the distribution of steel, but in all the activities of the people.

It might be impossible to effect an alteration sufficient to consume all the steel, seeing that this amount is to more than 30,000,000 gross tons a year, measured in the form of finished rolled steel, when prior to the war the production less exports was only about 20,000,000 tons; but our Allies have capacity to use much more steel than they can produce, and the shipping situation is such that we can transport a very large tonnage of steel to them.

Readers' Views and Comments

Intensive Toluol Production

To the Editor of Metallurgical & Chemical Engineering

SIR—In view of the great improvements in the recovery and manufacture of toluol carried out in this country since the war began, I was keenly interested to read the views of Mr. Lichtenhaeler in his article on "Intensive Toluol Production" in your issues for Feb. 1 and 15. The experiments and developments recorded are indeed worthy of the traditional thoroughness and skill of American engineers and chemists, but I may be pardoned in taking exception to a few of the principles as set forth in above article.

Under "Developing of Resources," questions of supplies are divided into three main arteries, crude petroleum products coming under item No. 3.

The writer has had considerable experience in the manufacture on a commercial scale of toluol from petroleum products, experiments being carried out with kerosene and fuel oils, and it can be definitely stated that at the present there is no "cracking" method which will give a satisfactory aromatic toluol. In the first place the approximate yield of pure toluol obtainable from crude oil is not more than 2½ per cent by volume, and actual costs including sale of by-products, such as gas, motor-spirit, etc., to produce one gallon of toluol in Great Britain was about $7.50. It is the writer's opinion that no method has yet been invented which is capable of yielding a toluol absolutely free from paraffins or cyclo-paraffins, which bodies tend to widen out the boiling range of pure toluol, and as proved by commercial-scale fractionation 0.5 deg. toluol cannot be produced from such sources, the same remarks applying to toluol from water-gas tar, or vertical-retort tar.

It is quite possible that the toluol produced distilling over a range of say 2 deg. C., can be nitrated and any paraffins or cyclo-paraffins separated by simple distillation. However, the presence of a small percentage of impurity such as the above has a tendency to detrain benzol into the toluol fraction, and this benzol seriously interferes with the resulting nitrated product, the merest trace of nitrated benzol in the nitrated toluol product causing the lowering of the melting point with consequent difficulty in the manufacturing process.

Referring to Fig. 1, it would be interesting to know how this process can be applied to coke oven plants or gas works dealing with say 2 to 5 million cubic feet of gas per day, as the cooling surface, etc., required would be enormous, and the plant as shown would require to be considerably modified in view of the necessary staging required.

With reference to the various efficiencies of the hurdle type of absorber, the "cap and bell" absorber and mechanical absorbers, the writer has had considerable experience in this direction, and can say with all confidence that the following are the relative efficiencies when operating on coke-oven gas and extracting benzol by means of creosote oil:

The hurdle type of scrubber has an efficiency of approximately 80 per cent. The cap and bell absorber, 85 per cent. Centrifugal scrubber of the MacLaurin patent type, 90-95 per cent.

The above figures, of course, refer to the standard sizes supplied for equal capacities of gas per hour, and I am at a loss to understand how the "cap and bell" scrubber, or any other type of scrubber can use a less quantity of oil if maximum recovery efficiency is to be obtained, as in all scrubbing and absorbing processes the efficiency of recovery is entirely dependent on the temperatures of the gas and scrubbing medium and the relative vapor tensions of the compound to be recovered in the absorbing medium and in the gas.

The so-called Carpenter process as employed in Great Britain was an emergency method put into operation at various small gas works which have not the necessary plant and apparatus to recover their benzol and toluol by the creosote oil absorbing process. It must be clearly understood that the calorific scale for the sale of gas is not universal in England, the photometric scale being more predominant, and in most cases the quantity of toluol recovered with tar as an absorbing medium is only 50 to 60 per cent of the actual quantity present in the gas. Most large concerns and coke-oven plants use creosote oil for benzol recovery, and it can be said without fear of contradiction that should the plant be so designed as to allow maximum heat interchange, etc., and careful control exercised, the absorbing oil will last easily two months. Due regard must be given to the back pressure which would undoubtedly be thrown on the exhauster by means of the "cap and bell" absorber as proposed, which from the illustration given, probably will amount to at least 30 in. water gage. Gas managers in the majority of cases would be unable to cope with such enormous resistance, and a scrubber is required, such as the MacLaurin centrifugal scrubber type which does not throw a back pressure on the plant of more than 1 in. water gage, whilst also giving definite relation between absorbing medium and the gas to be treated.

I question the statement whether the hurdle tower requires any more oil as stated than any other scrubber. Creosote oil as a washing medium is undoubtedly the most efficient for the recovery of benzol, and the loss in circulation is extremely small, whilst the price for spent oil approaches that of the fresh oil originally supplied to the plant.

Against the advantages of tar as an absorbent as set forth, we might state that for the same quantity of tar and creosote oil circulated, the former only gives a recovery efficiency of from 50 to 60 per cent, whilst the latter in most cases give 80 per cent, depending on the concentration of the benzol in the wash oil to a large extent, which normally approaches 4½ to 5 per cent.

Most gas and coke oven plants are not fitted with plant to distil their own tar, and should all the toluol and carbolic be recovered as stated, the price of the tar as sent to the distiller will be lowered proportionately. Should a shortage of absorbing oil at any time occur it is possible to substitute same by tar as

produced in the plant, and should this contain an excessive quantity of water, it would be entirely separated in a centrifugal scrubber, having the effect of washing the gas in two stages with water and tar respectively. With a good design of fractionating column and still, very little absorbing oil is carried over with the crude benzol, and in most cases does not amount to more than 5 per cent.

The type of still as shown, having closed steam coil in every section with open coil at the bottom, is now obsolete owing to the enormous wear and tear and erosion on these coils by the cyanogen sulphides and ammonia present in the tar and crude benzol, and which are evolved when subjected to the temperatures of distillation.

The most satisfactory method, and one which has been carried out and improved by the writer's firm, consists in preheating the ingoing oil and then superheating same by steam, passing back vapors and oil into the still separately, the oil being subjected to treatment with a very small amount of open steam, amounting to not more than 2 lb. per gallon of benzol recovered.

It is a moot point whether direct-fired stripping stills hold any advantage over the improved steam-heated type of plant, as the resulting benzol from the former contains a fairly large proportion of entrained higher boiling homologues in view of the absence of any fractionating device. Great risk of fire is also a drawback, and the wear and tear on the still through direct firing and the action of noxious gases is fairly high.

With regard to Article II, it might be stated that we have now had continuous stills in operation for a number of years and designed a complete continuous benzol refinery over twelve months ago (See "Gas World" 1917). With this type of plant it is possible to treat crude products with varying boiling ranges, as these are satisfactorily fractionated to standard products, which can easily be refined with very little still control, being fairly constant in composition. It is a practice in this country to treat say a coke-oven benzol distilling 65 per cent at 120 deg. C., (old retort test) and fractionate same into crude 90's benzol, crude 90's toluol, crude 90's solvent naphtha, crude 90's heavy naphtha, the various products oeing washed separately and fractionated through the continuous refinery and either 90's refined government standard or pure products manufactured in one continuous operation. Such treatment requires efficient columns and dephlegmators for the production of a compound such as pure benzene distilling 90 per cent over 0.5 deg. C. We have designed a new type of horizontal tubular dephlegmator in which the vapors pass through the tubes in a counter-current direction to the cooling water, thus ensuring maximum fractionation and gradual washing effect from the heavier condensed bodies. All returns, etc., are external, and same are easily cleaned in case of chokage by means of naphthalene or other deleterious matter.

With regard to the chemical treatment of crude benzol, this is bound to vary according to the source of the product, and no fixed basis can be taken.

When benzol or toluol is subjected to chemical treatment with sulphuric acid, should any toluol disappear, it is reasonably assumed that same has combined with the acid and formed a sulphonic compound. It is now possible to recover all the unsaturated bodies and aromatics which are lost in this manner. The acid tar is treated in the lead-lined vessel with open steam which decomposes the sulphonic bodies, which are carried over and condensed in special type condenser and subsequently separated and re-washed. The acid recovered amounts to approximately 90 per cent of the quantity used, only, of course, in a dilute condition.

Centralized refining must depend to a large extent on the freights charged for transport of crude benzol, but such a proposal undoubtedly calls for serious consideration after the war. B. DUNGLINSON.

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Central Stations and the Manufacture of Electrochemical Products

To the Editor of Metallurgical & Chemical Engineering

SIR:—No one who is in touch with the situation can entirely disagree with Mr. Winder as to the conclusions he reaches in his address on "Central Stations and the Manufacture of Electrochemical Products," published in your April 1st issue. His view that the power company which undertakes to furnish steam-generated electric power for an electrochemical industry labors under a serious handicap, is correct in part, for the reason that a 24-hour load accentuates the weakness of its high operating costs and minimizes the strength of its relatively low installation cost. This is especially true today when both installation and operating costs of the steam plant have soared to a much greater degree than has been the case with water-power plants.

Mr. Winder's discussion, however, is marked by one regrettable characteristic which has, as a rule, been common to similar discussions from the point of view both of the electrochemical manufacturer and of the central station industry, the apparent desire to prove a case rather than to learn the truth. As an electrochemist connected with a central station company, the writer feels privileged to criticize this attitude, which has, in the past, characterized both sides of the argument. An impartial statement must be based on all the facts and there are a great many facts to be considered from both points of view. General statements are dangerous because they are seldom based on a sufficiently comprehensive survey of the field as a whole. An analysis of the requirements of each electrochemical industry considered with relation to its possible use of steam-generated power in various parts of the country would be of great value, but such an analysis is difficult to make, and when made does not find its way into print.

The central station man who attempts such an analysis is faced by the fact that a great deal of absolutely essential information is unavailable, because it forms part of the secret stock-in-trade of the electrochemical manufacturer. The electrochemist who attacks the problem from the opposite point of view, although he has this information, will find that he cannot reach the solution without the assistance of someone who has a broad knowledge of central-station rate-making and the details of power supply as practiced by variously situated central station companies. Unless he is very careful

he will fall into the error of reaching general conclusions based on partial information.

Several errors of this nature have crept into Mr. Winder's article. He states broadly that, since central station companies do not produce 25-cycle power and such power is required by most electrochemical industries, this feature "practically precludes the present day central station from entering this field" (with particular reference to ferrosilicon manufacture). On the contrary several large central stations produce 25-cycle power and are prepared to sell it to anyone who prefers it. Mr. Winder implies that any power-factor much below 90 per cent is unacceptable to a central station company and that such a power-factor will increase the cost of power to the customer. As a matter of fact power-factors above 70 per cent are seldom penalized and one large power company, which penalizes any power factor below 60 per cent, gives a corresponding bonus for a power-factor above that value.

The off-peak rate is designed for use by the customer who can use such a rate to advantage, not for the industry which needs to maintain a 100 per cent load-factor 24-hour load. In Chicago the 24-hour load earns a rate very nearly as attractive as an off-peak load of similar proportions and the restricted peak period includes only four hours per day, four months in the year. The 24-hour load is nearly, but not quite, so desirable from the power company's point of view as the off-peak load, and the rate is fixed accordingly. Surely, under such circumstances, it is hardly fair to speak of "a twenty-four hour load undoubtedly penalized from a bookkeeping standpoint in favor of the domestic consumer," or to refer to "the inability of steam stations to make consistent rates for twenty-four-hour power."

When the economic value of power sources is being considered, the importance of their location must by no means be neglected, but when it is stated that the artificial abrasives industry cannot "stand more than a five-hundred-mile haul under the prevailing prices of water power," one begins to wonder. Where do the industries of the Middle West get their abrasives or are they still using the natural product? What portion of the United States can afford to use carborundum made at Shawinigan Falls? On this same 500-mile basis, isn't it possible that steam-generated power could profitably be used to manufacture abrasives to supply a well developed industrial territory situated more than 500 miles from the nearest developed water power available for this purpose?

The writer does not claim to know that steam-generated central-station power can be used economically in any wide degree by the electrochemical industries. To speak frankly, he doesn't know and hasn't so far been able to find out. Favorably located central-station power can be purchased in large blocks for from $50 to $60 per kilowatt-year, if it is to be used at a load-factor of 90 per cent or better for 24 hours per day; but that doesn't answer the question, nor does a learned discussion of freight rates fill the gap in the required information. What are the relative costs of the different factors involved in the various sorts of electrochemical manufacture? As those manufacturers are now conducted, what proportion of the total cost is represented by the bill for electric energy? Those who know won't tell and it doesn't pay to guess.

From some of the discussions of this subject which have been published one might assume that electrochemical industries, as a class, are burdened with power charges which form 50 to 75 per cent of their total cost of manufacture and distribution. But is this assumption a safe one? For example, consider the case of aluminium, which requires some 12.5 kilowatt-hours for every pound of metal made, and which Mr. Winder very properly specifies as "perhaps more dependent upon the low cost of power than any of the other above mentioned products." And yet, it is something better than a wild guess to estimate that the cost of carbon electrodes consumed per pound of aluminium is nearly as great as the cost of electrical energy, at the rates usually paid for energy in that industry.

One would suppose that the proper method to pursue in ferreting out the answers to all these questions—assuming that it is really desired to answer them—is for the electrochemical industries and the central station companies to get together for a full and frank discussion of the variables involved and their relative importance. A beginning along this line was made last year when a joint committee was appointed by the American Electrochemical Society and the National Electric Light Association, for the purpose of considering this very subject. The first report of this committee, however, does not give the impression that very much progress was made. Perhaps it is too much to expect that much progress can be made in a public discussion of economic matters, the true details of which are shrouded in secrecy and jealously guarded. The writer ventures to predict, however, that no general conclusions worthy of consideration will be arrived at, until our arguments pro and con, are based on the facts, all the facts there are, and nothing but the facts.

H. M. St. John.

Commonwealth Edison Co.,
Chicago, Ill.

Long-Range Bombardment of Paris

To the Editor of Metallurgical & Chemical Engineering

Sir:—The first day of the bombardment of Paris by the long-range German gun followed a night of bombing by enemy airplanes. No one at that time realized that shells were being sent into the city from a point behind the front-line trenches which are at least 75 miles from the center of the city. I was out on the streets the morning the bombardment began and everybody was under the impression that it was a *daylight* air raid, something entirely new, as of course all of the previous air raids had been engineered under cover of darkness. The sky above Paris was thick with French fighting planes, scooting here and there in search of enemy machines. It was not until late that day that we realized that the explosions did not come from bombs. The excitement was intense and everyone was mystified, for explosions were occurring at regular intervals of about twenty minutes, and no enemy machines could be spotted overhead.

The regular *alerte*, which is a warning sounded at the approach of German bombing machines, was given early in the morning, and both the "Metro" and the "Nord-Sud" the two Paris subways, were shut down in order that the stations platforms and underground tubes could be used as a refuge by the people of Paris. The

street railways stopped operation. Cars were emptied, motormen and conductors left their platforms, and the rolling stock was left standing in the street wherever it happened to be when the *alerte* was given. Traffic was absolutely paralyzed and the only wheels turning were those of the taxicabs.

As a matter of fact the shutting down of the subways in order to furnish underground retreats for the population defeated the very purpose for which it was done. In an hour or two people got tired of staying under ground and came up for a breath of fresh air. Many of them had to get from one part of the city to the other, and the only way of doing this was by walking along the streets. Therefore, with the subways shut down, there were far more people on the streets and subject to danger from explosions of shells than would have been the case if the lines had continued their normal operation. This fact evidently was appreciated later, for during succeeding bombardments by the long-range gun, the subway system has continued in operation.

The damage done by the long-range gun is much less than that which results from the dropping of bombs by an airplane. I have seen a good many of the buildings hit by the long-range shells and they seem to damage only the two upper stories. The bombs, however, wreck things to a greater depth, sometimes as much as four stories. It often happens that when a shell strikes, the panes of glass on the opposite side of the street are shattered, while those on the same side remain intact.

Detonations of explosives are such a regular event here that the store-keepers are going to great trouble to protect their windows from breakage. The favorite stunt seems to be to paste across the glass long strips of paper. It seems to me that these Parisian shop-keepers have something to learn in the matter of window protection from New York merchants, whose stores were situated along the excavations for the new subway lines. There it will be remembered the favorite trick was to truss the panes with diagonal wires and struts at the center. I have yet to see one of these rigs in service here. The gummed strips of paper, however, apparently have official sanction, for the windows of the Ecole Nationale des Ponts et Chaussees are dolled up in this way.

The city authorities are busy providing shelters or *abris* for the people during air raids. These are generally cellars of buildings not less than four stories in height. On the entrances to buildings containing cellars which have been officially designated as *abris* are big paper placards indicating the capacity of the shelter. Going along any street in Paris now you see on the buildings these placards with the words "150 places," "80 places," etc. Some of the cellar *abris* had window gratings fronting on the streets. At the present time all of these are being blocked up with plaster to intercept shell splinters.

Although the subway is now kept running during daylight bombardment by the big gun, it is closed during an air raid at night. Those people who seek underground shelter on such occasions now take the experience pretty much as a matter of course and during the last raid I saw people filing down stairs into the Etoile station of the "Metro" with camp-stools, chairs, newspapers and magazines, and other aids to comfort during the two or three hours sojourn below street level.

When a night raid starts the fire engines are sent at full speed through the streets with their sirens going full blast, church bells outside of Paris start ringing, and factory whistles add to the discord. New stationary sirens are in course of installation. Pretty soon the anti-aircraft guns start booming on the outskirts of Paris and from my window I can see the flash of the shells as they burst in mid-air. It looks just like the bunch of sparks produced in grinding metal with an emery wheel. In twenty minutes or so after the guns have started the airplanes which have managed to break through the barrage begin to "lay their eggs." It is very easy to distinguish between the detonation of bomb and the burst of the shrapnel from the "Archies." The bomb makes a deep long roar while the shrapnel produces a higher stacatto note.

An American where I am living arrived just in time to get in on one of the air raids. It was his first. The next morning he had a decidedly haggard look and I asked him what was the matter. He looked out of the window and seemed to be surprised that there was anything left of Paris. "They must have dropped about a thousand bombs last night," he said to me. I could not quite figure this out, as this was one of the nights that the bombing machines had failed to cross the barrage. Finally it dawned upon me that he had assumed to be bombs the detonations of the hundreds of shells which had been fired by the French artillery on the outskirts of the city to form the protective barrage. No wonder he was upset, as there must have been a good many hundred shrapnel fired that night. If these had been boche bombs I probably would not be writing this letter now.

Paris is not greatly disturbed by the shelling of "le canon a longue portee" which is generally dubbed by the French newspaper writer as "la grosse Bertha." People go about their business very much as usual. The moving pictures are taking a crack at the big gun in a humorous way. At the last performance I attended there was shown an "animated cartoon" in which "la grosse Bertha" was sending over shells and Charlie Chaplin (whom they call "Charlot" over here) was catching them, standing forth as the defender of Paris. After he had caught three of these the cartoon showed him juggling them, and finally hurling them back in the direction of Berlin.

While many people have departed from Paris as a result of the air raids and bombardment, the bulk of the population is taking the matter calmly. I have yet to see anything in the nature of a panic. At the pension where I live there is an elderly widow of a French general; she must be at least 70. When the bombs begin dropping she always goes through the motions of a mock courtesy in the direction from which comes the sound of the explosion. Only one or two of the crowd here seek refuge in the cellar. On several occasions they have tried to induce the old lady to descend with them, but she stands her ground, and all they can get out of her is, "Je reste ici."

R. K. TOMLIN, JR.

Paris, France

Mr. Tomlin is special war correspondent in France for *Engineering News-Record* and other McGraw-Hill engineering publications.—EDITOR.

Western Metallurgical and Chemical Field

Certain Influences on Electrochemistry and Metallurgy in California

The California Railway Commission has been conducting a comprehensive investigation into the need of immediate hydro-electric development to meet the special power consumption of war industries and the normal growth of the community. Their first report as to conditions in the southern part of the state shows that in that region an annual increase in hydro-electric plant capacity of 25,000 kw-hr. will be necessary to keep the oil consumption down to the present figure, and consequently recommends that the operating companies take immediate steps for financing these extensions to the extent of perhaps twenty million dollars. With promptitude and proper priority orders, this annual extension can be provided.

It is perhaps trite to remark that much of this shortage as well as the crying needs of nitrogen fixation and other electrochemical products would now be covered had not hydroelectric development been practically stationery throughout the United States for five years, on account of the lack of a comprehensive national water-power policy. The effect on present and future electrochemical and metallurgical industries in California is also obvious. In Secretary Lane's words, "It is quite manifest to me that there has got to be a very large electrical development if we are going to have the largest development along the lines of chemistry, and perhaps the best sphere for a young man for the next twenty-five years will be as an electro-chemical engineer in the United States. The water powers ought to be put into use now, not only with the idea of taking care of plants that will be commercially successful propositions, but with the purpose of experimenting and discovering what can be done." That the possession of developed water power is an asset of national importance in unexpected ways is shown by the effect of turning unsold power into ferro-manganese at Great Falls. This production will react favorably on the national railway and shipping situation, mining activity in the West, and steel production in the East.

Canadian Mineral Production

A preliminary report on the mineral production of Canada has been issued by John McLeish, Chief of the Division of Mineral Resources and Statistics of the Canadian Department of Mines. He notes that the metal production of 1916 showed a very large increase over that of the previous year, but in 1917 the net result in value has been an increase of only one-third of one per cent. The interrelation of the industry is shown by the effect of a diminished coal and coke output on the metallurgical production; the falling off in production of copper and gold is in part attributable to this cause. The accompanying table gives a view of the situation as a whole, both as to value and quantity.

The British Columbia production of copper amounted to 57,717,535 pounds; Ontario produced 42,796,213, derived chiefly from the nickel-copper ores of the Sudbury district, supplemented by a small recovery from the Cobalt silver ores.

Of the gold production, 27.5 per cent was derived from placer mining, 61 per cent in bullion and refined gold, and 11.5 per cent was contained in matte, blister and residues. Ontario produced 58 per cent of the total; British Columbia's production of $2,776,558 registered a decrease of nearly 39 per cent from that of 1916, due not only to the high cost of supplies but also in part to labor troubles and the closing down of the Rossland mines for several months. Yukon Territory produced $3,671,008 in gold, which is a decrease of over 16 per cent.

The lead production is largely from the Trail smelter in British Columbia, and the figure includes 30 million pounds of bullion, of which a large portion was electrolytically refined.

The 1917 production of nickel has, as usual, been derived from the ores of the Sudbury district, supplemented by a small amount of byproduct metal and compounds resulting from the treatment of the silver-cobalt-nickel ores of Cobalt. The Canadian Copper Company and the Mond Nickel Company produced 78,897 tons of nickel-copper matte, containing 83,773,319 pounds of nickel, and 42,392,588 pounds of copper, resulting from the smelting of 1,453,661 tons of ore. The refinery of the International Nickel Company at Port Colborne has not yet been completed, while the smelter and refinery of the British American Nickel Corporation near Murray, Ontario, is progressing slowly. Nickel to the extent of about 700,000 pounds was also recovered as a by-product from Cobalt ores in smelters at Deloro, Thorold and Welland.

Ontario produced 19,254,616 ounces of silver practically exclusively recovered from the ores of Cobalt and the adjoining silver camps. British Columbia produced 2,580,521 ounces.

During the past two years there has been a recovery of refined zinc in Canada at the zinc refinery erected at the Trail smelter, whose establishment has resulted in a largely increased tonnage of ores mined. The total zinc ore shipments from the mines were about 116,660 tons, containing 61,920,149 tons. Of this, British Columbia produced over 30 million pounds.

The pig-iron production by grades was as follows: Bessemer, 961,656 tons; basic, 14,092 tons; foundry and malleable, 181,041 tons; electric furnace pig, 15,000 tons approximately. No new construction of blast furnaces occurred, and the production of blast furnace pig fell off slightly. On the other hand a small production of high grade, low phosphorus pig iron was furnished from electric furnaces melting down shell turnings and other steel scrap, the salvage of which by this method promises much in the future.

The blast furnace plants operated were the Dominion Iron & Steel Company at Sydney, N. S., the Nova Scotia Steel & Coal Company, at North Sydney; the Standard Iron Company at Deseronto, Ont., The Steel Company of Canada, at Hamilton, Ont., The Canadian Furnace Company, at Port Colborne, Ont., and the Algoma Steel Corporation at Sault Ste. Marie, Ont.

Pig iron was made in electric furnaces by: The Canada Cement Company, Ltd., Montreal; Frazer, Brace & Company, Ltd., Shawinigan Falls, Que., British Forgings, Ltd., Toronto, Ont., Electro Foundries, Ltd., Orillia, Ont., and Turnbull Electro Metals, Ltd., St. Catharines, Ont.

MINERAL PRODUCTION IN CANADA

	1916		1917	
	Quantity	Value	Quantity	Value
Antimony ore, tons	885	$94,537	774	$50,476
Antimony refined, lb.	107,185	41,823		
Cobalt metallic and contained in oxide, etc., lb.	840,536	924,590	1,089,134	1,742,614
Copper, lb.	117,150,028	31,867,150	108,860,358	29,588,254
Gold, oz.	930,492	19,234,976	747,366	15,449,426
Iron, pig, from Canadian ore, tons	115,691	1,328,605	46,022	768,783
Iron ore, sold for export, tons	140,603	393,689	169,192	590,336
Lead, lb.	41,497,615	3,532,692	32,072,269	3,571,889
Molybdenite, lb.	156,461	156,461	271,530	271,530
Nickel, lb.	82,958,564	29,035,498	84,470,970	33,776,388
Platinum, oz.	15	600	49½	5,040
Silver, oz.	25,459,741	16,717,121	22,150,680	18,034,419
Zinc, lb.	23,364,760	2,991,623	31,227,351	2,779,547
	....	106,319,365		106,630,752

Manganese Concentrator at Philipsburg, Montana

A new system for the treatment of western manganese ores has been established by the Philipsburg Mining Company at Philipsburg, Montana, in a mill of 350 tons capacity. The mill has been in continuous operation since January 15, 1918, under the direction of Mr. R. S. Beitz, superintendent, and is doing exceptionally good work. The flow-sheet as operated at present is as follows:

The ore occurs in a limestone formation and the manganese is contained chiefly as a nodular variety of pyrolusite and psilomelane. It is brought from the mines a distance of approximately one and one-half miles in six-horse wagons holding between six and eight tons, and is dumped on a platform under which runs a 22-in. conveyor protected by an 8-in. grizzly. This conveyor elevates the material to a second grizzly having 2-in. spaces—the larger rock going to a No. 4 gyratory crusher and thence to the coarse-ore bin. The material under 2 inches is fed by a 22-in. conveyor to trommel No. 1, covered by 1½-in. round punched plates. This trommel revolves at 16 r.p.m. with a heavy spray of water thrown from all directions on the ore, washing the clay and sandy limestone from the coarser pieces.

The oversize from No. 1 trommel passes to a picking belt where two sorters reject the waste and lean ore; this reject returns to a set of 36-in. by 16-in. rolls, while the balance passes on to the coarse concentrate bin. The undersize from No. 1 trommel goes to the No. 1 elevator and is carried thence to No. 2 and No. 3 trommels. These trommels are identical, being covered for the first half by a ⅝-in. round punched plate, and the remaining with ¾-in. round punched plate. All the trommels in the mill are heavily sprayed with water.

The undersize from the ⅝-in. screen passes to No. 4 trommel, while the undersize from the ¾-in. screen goes to two double two-compartment Hartz bull jigs. The oversize from No. 2 and No. 3 trommels passes to the 36-in. by 16-in. rolls crushing the picking-belt reject, which operates in closed circuit with No. 1 elevator and trommels Nos. 1 and 2.

No. 4 trommel is covered with a four-millimeter round punched plate; the undersize passes to No. 5 trommel, and the undersize goes to one double two-compartment Hartz middling jig.

The No. 5 trommel is covered with one-millimeter diagonal slot screen; the undersize passes to a 10-ft. cone tank for dewatering before feeding to tables, while the oversize passes to two double two-compartment Hartz fine jigs.

The tailings from the jigs are returned to the 36-in. by 16-in. rolls and are reground, eventually appearing as table feed. The cup concentrates from the two bull jigs, together with the cup and hutch product from the middling and fine jigs are dewatered by a Dorr thickener, and then elevated to a steam-pipe dryer above the fine concentrate bin. The hutch product from the bull jigs is treated on one No. 5 Wilfley table; and the tailings from the middling and fine jigs are treated on three No. 6 Wilfleys. The fine sand which comes over the Dorr thickener is settled and again treated on one No. 6 Wilfley. The table concentrates pass to a conveyor and are elevated to a bin; the middlings and tailings go to waste.

A fair average of the assays is:

Heads, Mn 32%, SiO_2 35%; washed ore, coarse, Mn 41%, SiO_2 18%; concentrates, Mn 49%, SiO_2 9%.

Work of the Seattle Station, Bureau of Mines

The Pacific Northwest Experiment Station of the United States Bureau of Mines at Seattle is investigating electrometallurgical and ore dressing matters in cooperation with the College of Mines of the University of Washington, the School of Mines of the University of Idaho, and the Oregon Bureau of Mines and Geology, under the general direction of Thomas Varley, Superintendent.

The electrometallurgical laboratory is in charge of F. C. Ryan, and is equipped to make both electrolytic and thermoelectric investigations. The electrolytic apparatus consists of a 5-hp. motor-generator set capable of giving a current range of from 0 to 100 amperes and a voltage range from 0.25 to 15 volts, together with auxiliary equipment to take care of combined leaching and electrolytic problems.

The electrical equipment of the thermoelectric laboratory consist of two 140-kv.a. single-phase transformers with voltage regulators to give a range from 35 to 480 volts with transformers in single-, two-, or three-phase position, together with the necessary meters and pyrometers.

Field investigations in this department include a review of the present status of electrometallurgical plant development in the Pacific Northwest and southeastern Alaska, studying the general character of the work, equipment, and operating conditions. During the past year laboratory investigations were made on the utilization of metals from waste tin cans, and this problem is now well in hand. Investigations of ferromanganese and ferrochrome and other ferroalloys have also been made, the experiments being made on a small scale with the idea of experimenting on a large scale later.

Will H. Coghill, metallurgist, has carried on a study of the principles of ore flotation, the physical properties of oils being investigated and their modifying effect upon the surface tension of water determined. These surface tension tests are made with a "drop-weight" apparatus, which is essentially a dropping device provided with a brass tip, wherein the weight of the liquid drop that breaks from the tip gives a measure of the surface tension. The "capillary rise" method is unsatisfactory, but the drop-weight method, based on the well-known law of Tate, is so reliable and accurate that it should become better known. These tests have shown that the surface tension effect of oils is much less than the early technical literature would lead one to believe.

Another subject of investigation is on the angle of

contact between the liquid and the solid. This is recognized as one of the measures of "flotability"; many determinations are therefore being made and the theoretical and practical flotability of various solids on tranquil liquid surfaces are being compared. It has been determined mathematically that a solid, if not too large, is flotable when the angle of contact is greater than zero. Actual tests on tranquil surfaces have confirmed this analysis, but its relation to agitated surfaces is yet to be investigated. The so-called hysteresis angle is also receiving attention.

Work on gravitational ore-dressing has been under the direction of the superintendent of the station, Mr. Varley. During the past year a great many tests have been made on the massive copper-nickel pyrrhotite ore from Alaska, the idea being to make a separation of the copper and nickel from the related gangue. To date this work has been satisfactory as far as the copper is concerned, and some progress has also been made in recovering the nickel in a high-grade concentrate.

Following a visit to the Black Hills a number of samples of tin ores of that region were tested to determine what could be done in the way of recovering the cassiterite by concentration. At the present time very encouraging concentration tests are being made on low-grade chrome ores from Washington, Oregon and California. The same may be said of investigations now in progress on many of the quicksilver ores from plants in California which are using concentration as part treatment.

The work at the School of Mines at Moscow, Idaho, in charge of C. A. Wright, has been along the lines of preferential flotation, and consists of tests on the complex lead-zinc-iron ores of the Cœur d'Alenes. This work is made possible by the operators of the district who assisted in financing the work. The laboratory here has been made thoroughly up-to-date, and at the present time is one of the best equipped for ore-dressing in the West.

Company Reports

Consolidated Arizona Smelting Company.—The concentrator treated 106,226 tons of ore (an increase of 32½ per cent over that of 1916) containing $2.19 in gold and silver and 2.976 per cent copper. The recovery amounted to 90.4 per cent of the copper values, and 75 per cent of the gold and silver, with a concentration ratio of 3.14 to 1. The total cost of milling was $1.776 per ton of material treated, being 27 cents greater than in 1916, which increase was caused by the increase in wages and higher prices for nearly all kinds of supplies, but even to a greater extent by the attempt to fine-grind a larger tonnage that the equipment permitted, and the delays and repairs which naturally resulted. Additional ball mills are to be installed shortly to further increase the tonnage and improve the grinding and will also improve the recovery in the flotation machines. The total tonnage of new copper-bearing material smelted was 138,781 tons, an increase of 34 per cent over 1916 and 100 per cent over 1915. The production amounted to 9485 ounces of gold, 251,670 ounces of silver, and 19,751,042 pounds of copper. The average grade of smelter charge continued to show an increase in gold, silver and copper, the latter being now 7.85 per cent. The cost of producing copper has increased from 13.92 cents in 1914 to 14.98 cents in 1917. In conducting the custom smelting it is possible to equalize this advance by increasing the smelting charges. In purchasing custom ores the company endeavors to buy the copper and silver at the prices it expects to receive from their sale on the assumption of normal time in transit. Delays in the transportation of the blister copper to market during 1917 occurred when the market was falling, and the actual loss from this cause was approximately $120,000. Smelting costs, as shown in the accompanying table, are in part directly dependent upon the equipment. The steadily improved equipment has proportionately counteracted the other factors working even more strongly to increase the costs. Wages have increased 50 per cent during the last three years and coke has more than doubled.

Year	% Recov. Copper	Cost Crush. Receiving Samp. Stor. per T.	Cost Roast. & Reverb. Smelt., etc.	Cost of Convert. per lb. Copper Convt.	Cost of Frt. Ref. & Mktg. per lb. Copper Produc.
1913		$0.959	$4.097	$0.0137	$0.0139
1914		1.094	4.687	0.0058	0.0136
1915	83.978	0.543	2.844	0.0046	0.0153
1916	86.46	0.539	3.494	0.0072	0.0173
1917	90.70	0.489	4.200	0.0093	0.0218

The most serious failing of the smelter has been the heavy loss in metallurgical and mechanical dusting. Lack of roasting equipment has been remedied by the construction at a cost of $298,000 of four Wedge furnaces with Cottrell treaters, and an efficient system of belt conveyors. Over $100,000 was spent in remodeling and improving the equipment of the smelter, installing a third converter and a new crane, resulting in an increase in converting capacity of over 25 per cent. At Humbolt much work still remains toward improving living conditions. The company has always been seriously handicapped by inadequate and inferior living accommodations which have made it difficult to secure and retain the services of the best class of employees, and this condition has been emphasized by the recent influx of married men taking the place of the single ones who have been drafted.

North Star Mines Company.—A total of 126,474 tons was mined and delivered to the sorting plant, which eliminated 25,974 tons as waste, leaving 100,500 tons of ore which yielded values of $11.43 per ton, and a tailing containing about 40 cents. Of these values, 82 per cent were recovered by amalgamation and the balance by cyanidation. During the year $61,600 was expended, largely in equipping the Central Mill with sixty 1,500-pound stamps, and the enlargement of the Central Cyanide Plant, to perform the work formerly done by two 40-stamp mills with separate cyanide plants. The costs were as follows:

Milling	$0.611
Cyaniding	.458
Tailing Disposal	.028
Bullion	.034

on the basis of per ton crushed. G. B. Agnew, president of the company, remarks: "The purchasing power of gold has materially decreased each year of the war, with the result that the business of gold mining, generally has been seriously affected, and should the cost of supplies continue to rise, it is possible to foresee a situation where the Government might find it necessary to take measures to protect or to assist this important industry."

Hollinger Consolidated Gold Mines, Ltd.—This report shows a satisfactory financial progress, since in spite of the general shortage of competent labor a deficit of $269,590.93 existing on Jan. 1, 1917, has been converted into a surplus of $712,724.00 while during the year plant expenditures amounted to $673,237.52 (largely due to increasing the capacity of the mill at Timmins, Ontario, to 2500 tons per day) and $100,000 were written off for plant depreciation. Large additions to the physical equipment are now about completed, and its valuation amounts to $2,333,083.84. The mill worked at reduced capacity, treating all the ore which the mine was able to supply. Labor conditions were decidedly bad, especially during the first part of the year. Many of the miners are alien enemies, and while the average number of men employed was 1045, approximately 2700 men were hired and paid off during the year. Wages range from $4.00 to $8.00 per day. The report contains an unusually detailed distribution of expense, which would repay study, but which cannot be presented owing to lack of space. A comparison of operating results follows:

	1917	1916
Tons milled	514,301	601,584
Percentage of possible time running	70.2	91.1
Tons per 24 hours actual running	2007	1810
Stamp duty per 24 hrs. running	15.4	16.7
Solution precipitated per ton ore	2.15 tons	2.221
Average value per ton milled	$8.60	$8.84
Values in one ton of tailing	$0.31	$0.38
Cyanide consumed per ton ore	0.448 lbs.	
Zinc consumed per ton ore	0.36 lbs.	0.405
Lime consumed per ton ore	2.257 lbs.	2.113
Lead Acetate consumed per ton ore	0.331 lbs.	0.0042
Average value of pregnant solution	$4.038	$3.782

New Cornelia Copper Company.—The new leaching plant at Ajo was completed early in the year, and on May first the work of spreading the ores in the leaching tanks was commenced. The first shipment of electrolytic copper was made on June 18th, and the total since that time has been:

Electrolytic Copper	12,764,848 lb.
Cement Copper	3,316,283 lb.
Copper in shipping ore	3,401,060 lb.
Total	19,482,191 lb.

In addition to this there is 3,456,584 pounds of recoverable copper locked up in the process, including starting sheets, unfinished cathodes, solutions, and cement copper in launders. On the basis of copper shipped, the earnings were 19.5 cents per pound, and the expenses 15.8 cents. The difficulties experienced in starting the plant were not fundamental, and were easily overcome. The most serious was due to a lack of the proper number of launders for the precipitation of cement copper. The amount of iron and alumina dissolved from the leaching ores builds up in the solution, and it is necessary to continuously remove a large percentage of the returning low-copper electrolyte, replacing it with fresh acid and water. While additional precipitation launders were being built, the solutions became supersaturated and the extraction ran down from 80 per cent to as low as 65 per cent. In the future, steps will be taken to decrease largely the amount of copper recovered in the cementation tanks, since the latter costs two cents per pound more to make, and suffers a deduction of 3 per cent for smelting loss as well. The hard lead anodes which were possible sources of trouble in the electrolytic tanks show no serious corrosion after months of use. Two additional towers for the reduction of ferric salts by means of SO_2 gas have been constructed, which towers show an absorption of over 80 per cent. With this new equipment, it is thought possible to make a total production of over four million pounds of copper monthly, instead of the three million originally planned. During the year a favorable contract with the Minerals Separation Co. was signed, and a test plant will shortly be erected to devise the proper grinding equipment and a flow sheet for the sulphide ores. Mining operations in the oxidized zone will probably uncover in three years a sufficient quantity of sulphide ores to justify a flotation plant of 10,000 tons daily capacity.

The McKinley-Darragh-Savage Mines of Cobalt, Ltd.—This report calls attention to the fact that the average price for silver received was larger during the current year than previously, but this increase was more than offset by the added expense of labor and material, and the decreasing silver content of the ore. The general relation of production to costs and receipts for the past few years is clearly shown in the following table:

Year	Ounces recovered	Average Price Received	Total Costs	Net Profit
1912	2,717,383	$0.6166	$0.1859	$0.4307
1913	2,214,036	0.5919	0.2233	0.3686
1914	1,396,540	0.54385	0.31325	0.2306
1915	1,107,815	0.50785	0.2871	0.22075
1916	925,779	0.67364	0.4073	0.26634
1917	908,756	0.832	0.5709	0.2611

The total tons of ore treated in the mill amounted to 68,142, or an average of 197.56 tons per day. The average mill heads were 13.434 ounces silver per ton, tails, 1.795 ounces, giving an extraction of 87 per cent. During the year a mill was built to re-treat the accumulated tailings, which was fully equipped with the exception of the necessary grinding machinery. The mills were promised for delivery June 15, 1917, but had not yet arrived on Feb. 1, 1918.

Calumet and Arizona Mining Company.—In the reduction works at Douglas, Arizona, two blast furnaces operated a total of 689 furnace-days and smelted a total of 585,975 tons of ore. With an average of 13.3 furnaces operating in the roasting department, 451,255 wet tons of ore were reduced from 31.6 per cent sulphur to 10.2 per cent. The decreasing ratio between oxidized to sulphide ores tends to the reduction of the grade of matte, and greatly embarasses the converter department. A crushing department to operate on roaster charge is therefore in contemplation, which will enable the production of calcine containing about 6 per cent sulphur. Four reverberatory furnaces operated a total of 1419.2 furnace-days and smelted 420,458 tons of calcines, 62,871 tons of fettling, 27,173 tons of flue dust and 14,505 tons of flux. Additional waste heat boilers are to be installed, which will largely augment the excess power generated over that required to run the smelter, and which is now being transmitted to the mines in Bisbee, up to an eventual total of about 1700 kilowatts. The 200-ton acid plant started operation in March, and has operated successfully since the start. Five roasters deliver gases averaging 5.67 per cent SO_2 at a temperature of 840 deg. F. The total production has been 50,225 tons of 50 deg. Baumé acid, while the daily average since October first has been 223 tons.

Notable Meeting of the American Iron and Steel Institute

A NOTE of optimism dominated the fourteenth general meeting of the American Iron and Steel Institute in New York on May 31. At the annual banquet 1100 guests listened intently as Judge GARY, CHARLES M. SCHWAB and J. L. REPLOGLE told of the part the iron and steel industry is playing in the war. The audience was repeatedly roused to a high pitch of enthusiasm as the speakers expressed in patriotic terms the determination to win the war and obtain peace through victory.

JUDGE GARY'S ADDRESS

By way of emphasizing the fact that we must constantly look forward and not be concerned with the mistakes of the past, Judge GARY said:

"It would be useless to discuss what ought to have been done to prevent certain conditions. We are not at this time particularly concerned with the past. It would not be useful now to refer to the awful things that are being done in Europe, except for the purpose of emphasizing in the strongest words and in the best possible manner the fact that we personally are not without courage, we are not without vision, we are not without appreciation of our responsibilities.

"The steel industry is doing much to assist in carrying on this war. The American Iron & Steel Institute has been carrying on a very large work. It is in close communication with the Government officials all the time. It is a source of securing information and of distributing it to the Government officials. It is the agency upon which the Government depends very largely for its assistance in carrying on many of the activities essential to the war.

STEEL INDUSTRY IN GOVERNMENT FAVOR

"We find to-day Government officials in high places coming to the steel men with the statement that they want to co-operate with us, that they want our assistance; that they depend upon our loyalty and our ability to assist the Government in this time of great distress.

"It is to my mind a source of gratification that we may look forward to the future with hope and expectation that the Government of the United States is going to assist, to foster prosperity and business enterprise, instead of attacking it.

"We are doing another thing, gentlemen, and the Government is permitting us, assisting us, urging us to do it. We are day by day putting our affairs in better shape; we may not be making so much money, or if we do make it we may be paying it out in taxes and in extensions to our works for the benefit of the Government at such cost that we are absorbing our profits, but, nevertheless, we are putting our works in better condition; we are being better prepared for the future, the iron and steel industry will be on a better basis and a better footing than ever before; well prepared to succeed in the contest and the competition for international trade. If we win the war, that will be worth something to us, if we do not save much in cash. If we lose the war then it is not so important whether we have anything or not."

REPLOGLE PLEADS FOR EXTRA TONNAGE

J. L. REPLOGLE, director of steel supply, devoted his remarks mainly to the increasing war demand for iron and steel, and emphasized the necessity of producing an extra tonnage in those lines of steel products necessary to win the war. "War necessities is a rather flexible term," he said, "and it has been given much thought and consideration by those in authority at Washington."

"I had a conference Wednesday with the representative of the corset industry. It developed that their profits last year from this great industry aggregated $40,000,000, and that they require 15,000 to 20,000 tons of high carbon spring steel annually. I am no authority on corsets, but I must confess that after a complete discussion of the subject I was not prepared to dispute their claim that corsets were absolutely an essential.

"There have been many lists of so-called non-essential industries prepared at Washington, but they have never been officially issued, as there has never been complete agreement on this subject. All industries are essential from one standpoint or another—if no other, from the standpoint of the owner, and we have preferred to reverse the procedure and prepare a list of the more essential industries, giving them such preference in steel supply, fuel, transportation and labor as are necessary to get the results for which we are all striving.

"It may be surprising to many of you to learn that we now have unfilled orders on the books of the steel manufacturers and on our desks at Washington for 16,800,000 tons of steel for the United States and Allied Governments and the orders are coming in at a greater rate than they are being executed, although I believe we are near the peak of production. Difficulties of some of our gallant Allies are very great. Coal in Italy is $140 per ton, and its steel industries are working under great disadvantages. A very large per cent, probably 75 to 80, of the steel and coal in France is now either in the hands of our enemy or within the range of his guns. The requirements of our Allies will be enormous and the least we should do is all that we can do to give them steel when and as needed.

"The railroads of our country need more rails for safety and efficiency of operation, and it is difficult to give them any increase without restricting the production of projectile steel, which is largely rolled on rail mills. The forging plants are now getting under way, and have just reached the point where their consumption of projectile steel will be an extremely heavy factor. The shipyards have their ways built and many keels laid, and under the direction of Mr. Schwab will require vast tonnages of steel. His program for next year is at least double that of this year, and we must furnish him the steel to complete the great work he has to do and for which he is so well qualified."

SCHWAB SAYS ENCOURAGEMENT, NOT CRITICISM, NEEDED NOW

The hearty approval of the appointment of Mr. SCHWAB as director general of shipbuilding was voiced by the applause which greeted him as he rose to speak. He prefaced his remarks by saying that he was burdened with the great responsibility and with the

thought that the unmeasured confidence of his friends must not be disappointed.

"We all seek the encouragement and approbation of our fellowmen and I rejoice that because the great steel industry has given its approval of my selection, there has come greater enthusiasm and patriotism to men throughout the country which will mean much in winning this war; but, after all, no individual can be a very great factor. The undertaking is so vast that we must have the hearty support of every man, woman and child in the country. Some of us have been prone to criticise, but I should not be fair if I did not say that the work of Hurley, Piez, Goethals and others has been magnificent. When this country entered the war, all the shipyards were engaged in building ships for the navy and the yards for other ships had to be created. I have examined 65 to 70 per cent of the shipbuilding capacity of the country and I wish to say that the accomplishment is wonderful. What is needed now is not criticism, but encouragement.

"During May the United States finished and placed in commission 250,000 deadweight tons of ships. Every workday two such ships as that launched yesterday by the Submarine Boat Corporation were finished, and May will be the month of least production. I do not intend to indulge in prophecy, for that is dangerous, but I will say that you will not be disappointed. It is necessary that every industry connected directly or indirectly with shipbuilding shall be enlisted in the great work. So stupendous is the number of ships that the contracts for new works now aggregate $250,000,000. On the Great Lakes from 400,000 to 500,000 tons will be built this year, but that is not enough and capacity will be increased so that next year 1,000,000 deadweight tons will be produced. I am not worried about the steel, for I believe that it will be produced. The industry has more loyally come to the support of the Government than has the great steel industry. The shipbuilding capacity will be increased wherever necessary."

Technical Papers Presented

At the technical session the following papers were read:

The Electric Steel Plant at South Chicago, by T. W. Robinson. The Design of the Modern Blast Furnace Stack, by J. G. West, Jr. The Modern By-Product Coke Oven and Its By-Products, by W. H. Blauvelt. Effects of Phosphorus in Soft Acid and Basic Open Hearth Steels, by J. S. Unger. Conservation of Ferro-Manganese, by C. R. Ellicott. Relation of the Trade Papers to the Iron and Steel Industry, by Bertram S. Stevenson.

Manganese Price Scale

Schedule for Domestic Product Premiums and Penalties

THE War Industries Board has approved the scale of prices agreed to by the American Iron and Steel Institute. The following schedule gives domestic metallurgical manganese ore prices per unit of metallic manganese per ton of 2240 lb. for manganese ore produced and shipped from all points in the United States west of South Chicago, Ill. This schedule does not include chemical ores as used for dry batteries, etc. The prices are on the basis of delivery f.o.b. cars South Chicago, and are on the basis of all-rail shipments. When shipped to other destination than Chicago, the freight rate per gross ton from shipping point to South Chicago, Ill., is to be deducted to give the price f.o.b. shipping point.

For manganese ore produced in the United States and shipped from points in the United States east of South Chicago, 15c. per unit of metallic manganese per ton shall be added to above unit prices.

Above prices are based on ore containing: Not more than 8 per cent silica and not more than 0.25 per cent phosphorus, and are subject to:

Silica Premiums and Penalties: For each 1 per cent of silica under 8 per cent down to and including 5 per cent, premium at rate of 50c. per ton. Below 5 per cent silica, premium at rate of $1 per ton for each 1 per cent.

For each 1 per cent in excess of: 8 per cent and up to and including 15 per cent silica there shall be a penalty of 50c. per ton; for each 1 per cent in excess of 15 per cent and up to and including 20 per cent silica there shall be a penalty of 75c. per ton.

For ore containing in excess of 20 per cent silica, a limited tonnage can be used; but for each 1 per cent of silica in excess of 20 per cent., and up to and including 25 per cent. silica, there shall be a penalty of $1 per ton.

Ore containing over 25 per cent silica subject to acceptance or refusal at buyer's option, but if accepted shall be paid for at the above schedule with the penalty of $1 per ton for each extra unit of silica.

All premiums and penalties figured to fractions.

Phosphorus Penalty: For each 0.01 per cent in excess of 0.25 per cent phosphorus there shall be a penalty against unit price paid for manganese of ½c. per unit figured to fractions.

PRICES PER UNIT OF METALLIC MANGANESE FOR ORE CONTAINING WHEN DRIED AT 212 DEG. FAHR

	Per Unit
35 to 35 99 per cent, inclusive	$0 86
36 to 36 99 per cent, inclusive	90
37 to 37 99 per cent, inclusive	94
38 to 38 99 per cent, inclusive	98
39 to 39 99 per cent, inclusive	1 00
40 to 40 99 per cent, inclusive	1 02
41 to 41 99 per cent, inclusive	1 04
42 to 42 99 per cent, inclusive	1 06
43 to 43 99 per cent, inclusive	1 08
44 to 44 99 per cent, inclusive	1 10
45 to 45 99 per cent, inclusive	1 12
46 to 46 99 per cent, inclusive	1 14
47 to 47 99 per cent, inclusive	1 16
48 to 48 99 per cent, inclusive	1 18
49 to 49 99 per cent, inclusive	1 20
50 to 50 99 per cent, inclusive	1 22
51 to 51 99 per cent, inclusive	1 24
52 to 52 99 per cent, inclusive	1 26
53 to 53 99 per cent, inclusive	1 28
54 and over	1 30

In view of existing conditions, and for the purpose of stimulating production of domestic manganese ores, there will be no penalty for phosphorus so long as the ore shipped can be used to advantage by the buyer. The buyer reserves the right to penalize excess phosphorus as above by giving 60 days' notice to the shipper.

The above prices to be net to the producer; any expenses such as salary or commission to buyer's agent to be paid by the buyer.

Settlements to be based on analysis of ore sample dried at 212 deg. Fahr. The percentage of moisture in ore sample as taken to be deducted from the weight.

Rubber Substitutes

Factors and Limitations to Be Considered in Studying Rubber Substitutes—Extensive Use of Reclaimed Rubber and Mineral Rubber Decrease Demand for Oil Substitutes in This Country—Glue Substitutes Still Experimental

By ANDREW H. KING

STRICTLY speaking there is not, nor ever will be, a true rubber substitute. A substitute is something which may be used in place of another substance. It is therefore implied that a true rubber substitute would possess physical properties equivalent to rubber. The chemical properties are in most instances merely side issues. It is the valuable physical characteristics of rubber that are desired. These properties are not well known by the people in general, and even many men who work with rubber can not tell you why it is valuable. As a consequence, this field has been the playground for amateur inventors for over fifty years. Thousands of patents have been taken out and much valuable time, energy, and material spent in developing compositions, only to find them without any particular value. Each inventor applied the term "rubberlike" to his product, and thought he had made his fortune. Almost as many separate attempts are recorded in this field as in the pursuit of perpetual motion.

The reasons for this great amount of effort are simple to arrive at. First, rubber is valuable and a true substitute would undoubtedly bring the inventor a considerable sum of money. Second, very few if any of the investigators in this field had the least conception of the properties of rubber. Third, it is extremely easy to make preparations which to the uninitiated resemble rubber. As a result dabbling in rubber substitutes was formerly sort of an apprenticeship course for the amateur inventor.

A DEPOSIT OF GILSONITE

The Valuable Properties of Rubber

But what properties do make rubber a valuable material? Perhaps the most important is the extreme ease with which so many varied effects can be secured. Its adaptability is unrivaled. For example, one can obtain by suitable compounding from the same variety of rubber, stocks which will test as follows:

1. Tensile strength 3500 to 4000 lb. per sq.in. Stretch 2 in. to 14 in. (600%). — A tire-tread stock, very tough, resilient, not very hard.
2. Tensile strength 300 lb. per sq.in. Stretch 2 in. to 20 in. (900%). — A tire-tube stock, very stretchy; strong; will not tear readily.
3. Tensile strength 2000 lb. per sp.in. Stretch 2 in. to 22 in. (1000%). — An extremely soft and stretchy stock. Suitable for frictions.
4. Tensile strength 2200 lb. per sq.in. Stretch 2 in. to 10 in. (400%). — Very stiff, hard stock; resists wear; suitable for solid tires.
5. Tensile strength 6000 lb. per sq.in. Stretch zero. — A hard rubber.

The stretch may be varied from zero to 1000 per cent; the tensile strength from 1000 to 6000 lb. per sq.in.; the hardness may be anything from that of hard rubber to that of a soft, stretchy tube-stock. Many stocks, as for example the tread of a tire, are exceedingly tough and show great resistance to cutting and tearing. Tube-stocks are much more stretchy, but they also resist tearing to a marked extent. The addition of substitute to rubber decreases the tensile strength without greatly altering the stretch. The effect is dilution, and the more substitute present the weaker the stock.

Capacity for Absorbing Fillers

Another important property of rubber is its ability to take up and hold in solid solution large amounts of various inorganic and organic fillers. Crude rubber when properly manipulated will take up one-third of its own volume of fillers and still produce a product having desirable physical properties. Such a stock may have a tensile strength of 2800 lb. per sq.in., and a stretch of 500 per cent. The addition of a larger volume of filler is not desirable since from this point on tensile strength, etc., rapidly fall off. It is possible, however, to add to rubber up to one-half its volume of filler, but the product is of very little value. By volume of filler I mean true volume, weight divided by specific gravity, and not apparent volume. No substitute so far developed can even approach this record.

Under the head of substitutes I will take up not only the common oil substitutes known to the compounder as "subs," but various other related filling materials whether of an oily or asphaltic nature. These substances, while not true substitutes, do have certain valuable properties when used in the right way. Their general effect is to soften stocks which would otherwise be hard and stiff. Being of low gravity they tend to lower volume costs. Very often they are themselves sticky or tend to make the compound tacky. Consequently they find limited application in friction stocks. Certain of the asphalts and parafin tend to decrease porosity and permeability, and thus increase insulation.

The substitutes which have been proposed from time to time may be classed as follows:

1. Oil products, known to the compounder as subs
2. Asphaltic materials
3. Resinous substances
4. Greases
5. Waxes
6. Glue

Sub

Under this head may be placed those oil derivatives which are listed in market reports as "Rubber Substitutes." The methods of manufacture are as follows:

a. By addition of sulphur chloride to either the raw or blown oil.
b. By boiling the raw or blown oil with sulphur.
c. By heating and blowing with air, or adding nitric acid to the partly blown oil.

The oil substitutes come on the market in two principal classes, namely: white and brown (black). The first is prepared solely by means of sulphur chloride (method *a*), the second by methods *b* or *c*. The vegetable oil employed depends primarily on the market prices, the aim being to use the cheapest obtainable. These oils, as is well known, consist chiefly of glycerides of unsaturated fatty acids. Among vegetable oils the degree of saturation varies. The oil may be nondrying such as cottonseed, semi-drying such as rape or colza, or a drying oil like linseed. From any of these a good sub can be prepared by one or the other of the above mentioned methods. How wide the degree of saturation may vary is indicated in the following table of iodine values (Hehner).

Oil	Iodine Value
Linseed	170—200
Tung	150—170
Castor	82 — 90
Rape, Colza	92—109
Corn Oil	111—124
Poppy Seed	133—143
Cotton Seed	104—116
Olive	79— 90

Each maker of substitutes has his own procedure, and the value of his product depends primarily on how carefully he has attended to the details. White substitutes are chiefly chlorosulphides of fatty oils; brown (black) subs are either sulphides of fatty oils, oxides of triglycerides, or mixtures of the two.

1. Vegetable Oils

The following oils are the principal ones which find application:

Linseed, expressed from flax seeds.

Tung (China wood oil) obtained from the nuts of the tung tree.

Castor, secured from the castor bean.

Rape and colza are two oils from slightly different sources but have almost identical constants. They are obtained from plants grown extensively in Europe.

Corn is from the germ of Indian corn.

Poppy seed, expressed from the fruit of the poppy.

Cottonseed, expressed from cotton seeds.

Olive, expressed from olives.

(a) Addition of Sulphur Chloride

There is but little definite knowledge of what actually takes place when oils are treated with sulphur chloride, S_2Cl_2. The action is probably similar to the old vulcanization of rubber which produces an addition product $(C_{10}H_{16}S_2Cl_2)_x$. On adding sulphur chloride to a fatty oil a homogeneous mixture is obtained, which is followed rapidly by an energetic reaction accompanied by evolution of heat. Vapors of sulphur chloride, a little sulphur dioxide, and some hydrochloric acid are evolved. After a few minutes the mixture sets to a solid, yellowish white, rather elastic mass, which may be easily crushed in a mortar. On exposure to air any excess of sulphur chloride evaporates and a neutral substance is obtained. C. O. Weber[1] gives the following proportions of oil and sulphur chloride which he found satisfactory:

100	parts	linseed oil	with 30	parts	S_2Cl_2
"	"	poppy seed	" 35	"	"
"	"	colza, rape	" 25	"	"
"	"	cotton seed	" 45	"	"
"	"	olive	" 25	"	"
"	"	castor	" 20	"	"

There is evidently no relation between the drying power of an oil and the proportion of sulphur chloride it requires to form a solid substance. It has been found in practice that the high temperature resulting from the action of sulphur chloride on the oil is not desirable since it frequently causes carbonization. Consequently it is generally diluted with some solvent, such as light gasoline or carbon tetrachloride. It is also customary to cool the mixture, thus retarding the reaction. If the heat is removed as fast as produced one obtains a perfectly white substitute. The temperature range should not exceed 80 to 100 deg. C. An old recipe for dry white floating substitute is as follows:

15 kg. castor oil, 10 kg. rape, 5 kg. sulphur chloride in 1 kg. of light petroleum benzine.

The product is ground, spread in trays, and placed on racks to age. On alternate shelves are placed other trays of hydrated lime, which absorbs any sulphur chloride or hydrochloric acid that may be given off. Towards the end of the ageing period a small amount, never more than 5 per cent of magnesia is sometimes dusted over the sub to neutralise any remaining acid. The material is then ready to be sacked for shipment.

The above proportions of oil and sulphur chloride give an absolutely dry substitute. If a more greasy, or tacky one is desired, the quantity of sulphur chloride is lowered and the castor oil omitted. The recipe is now:

25 kg. rape, 1.3 kg. S_2Cl_2, 1 kg. light benzine.

The amount of sulphur chloride can be considerably reduced by using a brown oil. Thus blown cottonseed oil

requires only 20 per cent of its weight of sulphur chloride, while the raw oil requires 45 per cent.

(b) Heating with Sulphur

This method or some modification of it is most in use. The process consists essentially of heating an oil or mixture of oils to a rather high temperature, adding sulphur, and maintaining the heat for a certain length of time. The procedure is varied by the different manufacturers, but the following is a representative sample: 100 kg. of raw rape oil is heated in a boiler with 18 kg. sulphur to 160°-200° C. with constant stirring. The oil is first brought to the required temperature and the sulphur added. This may be in any form, provided it is free from acid, since all varieties melt at this temperature. The reaction is exothermic and once started the fire can be withdrawn. The end point is indicated by considerable foaming and rising in the kettle. The contents are then poured into pans to cool and congeal. At 145 to 155 deg. C. under pressure this sub flows like a viscous fluid. A much smaller amount of sulphur is necessary if the oil has been previously thickened by heating and blowing with air.

(c) Blowing With Air

The oil is heated in large open kettles to 160 deg. C. or above and air is blown through for some time. The speed with which it thickens up depends to a great extent on whether it is a drying or a non-drying oil. Thus linseed oil thickens up quickly but cottonseed requires a much longer time. China wood oil congeals in a very few minutes when merely heated to 250 deg. C. With the average oil mixtures the heating and blowing is continued until a small sample when cooled sets to a mass having the desired degree of toughness, elasticity, etc. In fact, this is the general procedure followed in all substitute experiments.

Sometimes the oxidation is catalysed by the addition of a small quantity of lead or manganese oxides. Lime or magnesia may also be used. The employment of lead or manganese oxides is not to be countenanced, because these substances bring about oxidation of the rubber, thus producing a poor ageing stock.

Addition of Nitric Acid to a Blown Oil

A very fine, light substitute is made in this manner. An example is as follows:

Nitric acid which has been diluted with twice its volume of water is added to a partly oxidized oil and the mixture boiled and blown until the reaction has gone as far as desired. On cooling the product is ground and washed well with water to remove all the acid. Just the right amount of acid must be added or the preparation will be spoiled.

With sulphur chloride one can obtain a nice, dry substitute, or a tacky one as desired. By suitable combination of blowing and addition of sulphur any degree of hardness, from a soft, sticky mess to an extremely hard, black resinous mass, can be produced. It matters little what oil the substitute is made from provided it is well prepared. It is frequently adulterated with paraffin, vaseline, or even mineral oil. A small quantity of paraffin is harmless, but mineral oils are certainly not. Free vegetable oil is much less destructive but is not particularly desirable. The free sulphur content must be known and allowed for in compounding the material. In order to cheapen their product some makers will add even as high as 20 per cent (by weight) of inert material such as barytes or aluminium flake. This is not often met with, however, since sub is always supposed to be of low gravity and is recommended for floating stocks. In general the ash should be very low. This merely insures the compounder that his sub is pure and he is getting value for his money. For obvious reasons the sub should contain no mineral acids and should not contain any ingredients which are liable to bring about spontaneous oxidation. In the end there is only one real test: that is actual trial. A new variety of sub should not be put into use until thorough age tests have been performed.

As previously stated, these substances are not in any sense real substitutes, and their true nature, which is that of fatty oils, is not altered by the vulcanization through which they have passed. They are still triglycerides, and therefore saponifiable. To this fact their limited use is due. They will not withstand high temperatures, steam, etc., and always decrease the strength of the rubber with which they are mixed. The sulphur content in white subs does not usually exceed 7 per cent. In the brown or black varieties it may vary from 3 to 20 per cent. Subs are insoluble in alcohol and acetone, and also insoluble in the usual rubber solvents but swell in them. Treatment with alcoholic potash always saponifies and dissolves them. About ten years ago every rubber laboratory kept a large bottle of this solution in stock solely for the examination of new substitutes.

Analytical: The first work on this subject was done by R. Henriques.[2] His results are often quoted and are still of value. They are given in Table I.

TABLE I.

	Commercial Products					Linseed Oil		Colza Oil		Poppyseed Oil	Castor Oil Sub		Sub from Oxidized
	White Substitute			Brown (Black) Sub		Sub from		Sub from		Sub from	With Min. Amt.	With Max.	Cotton-Seed
Determinations	A_1	B_1	C_2	A	B	Fresh Oil	Blown Oil	Fresh Oil	Blown Oil	Blown Oil	S_2Cl_2	Amt. S_2Cl_2	Oil
Sulphur in the substitute	6.4	6.17	8.25	15.48	17.71	9.34	4.78	8.28	6.59	7.68	4.82	10.6	6.23
Chlorine in the substitute	5.0	5.86	8.88	0.7	0.36	8.84	4.85	7.62	5.95	7.44	6.70	8.95	5.36
Water in the substitute	0.85	1.00	.....	.....	.....	3.02	0.85	....	....	....	....	....	....
Residue on ignition	0.8	5.51	.....	.....	.....	....	....	....	....	....	....	....	....
Fatty acids	90.45	73.58	.....	.....	.....	79.6	81.67	87.95	74.9	85.35	....	....	....
Sulphur in the fatty acids	6.12	6.45	8.15	14.14	15.2	9.88	4.06	8.34	6.54	8.32	5.32	....	6.44
Chlorine in the fatty acids	0.83	0.43	....	....	....	Trace	0.60	Trace	Trace	...	0.26	Trace	Trace
Iodine absorption of substitute	30.9	31.0	32.6	42.0	42.0	56.3	52.6	32.5	26.9	33.6	35.2	21.9	30.3
Iodine absorption of fatty acids	91.3	91.2	102.3	129.0	125.6	160.3	141.2 121.0	101.5	102.8	133.3	136.2 147.4 152.1	143.5	91.5
Acetyl number	....	....	....	....	....	21.0	19.6	31.0	....	....	....	105.6	51.3

A_1 and B_1, from oxidized oil. C_2 from raw o'l.

[2] *Chem. Zeit.* 1893, 17, 634-638.

The determinations usually made are:

1. Acetone extract, which removes
   - (a) Unvulcanized oil
   - (b) Unsaponifiable matter, which includes
     - (1) Paraffin which is crystallized in the usual manner
     - (2) Mineral oil which is indicated by a flourescent extract
   - (c) Free sulphur.

   White sub contains from 1 to 2 per cent free sulphur. Over 3 per cent shows defective manufacture or reversion during storage.
2. Chlorine
3. Total sulphur
4. Acidity

   Dubosc states that there is always free acid, which is rarely in excess of 2 per cent. This is due to oleic acid. Dissolve in neutral alcohol and titrate. For mineral acid, which should be absent, extract with hot water and titrate.
5. Ash

   For brown sub 1 per cent is about the limit. In white subs a little lime or magnesia will usually be found. The latter should be in excess, since in the presence of a little oil it gives a non-deliquescent oxychloride. The presence of hygroscopic substances causes sub to decompose in storage.

TABLE II. WHITE SUB

Make	English Per Cent	German Per Cent	French Per Cent
Non-vulcanized oil	10.3	7 7	13 8
Free sulphur	0 8	0 3	2 1
Vulcanized oil (by difference)	86 2	89 4	81 3
Combined sulphur in extracted sub	6 7	7 2	6 4
Chlorine	7 8	7 7	7 2
Ash	1.0	2 6	2.8

TABLE III. BROWN SUB WITHOUT HYDROCARBONS

Make	English Per Cent Hard	English Per Cent Hard	German Per Cent Medium	German Per Cent Soft	French Per Cent Medium
Variety					
Non-vulcanized oil	21 7	9 6	22 7	17 2	23 6
Free sulphur	0 3	0 1	0 2	0 1	1 5
Vulcanized oil (by difference)	77 1	90 2	77 0	82 5	74 3
Combined sulphur	13 1	16 3	7 1	10 2	9 8
Ash	0 9	0 1	0.1	0 1	0 6

TABLE IV. BROWN SUB CONTAINING HYDROCARBON

Make	English Per Cent	German Per Cent	German Per Cent Fine Para	French Per Cent Fine Para
Variety				
Non-vulcanized oil	25 1	10 6	25 0	23 4
Free sulphur	2 5	1 6	0 5	0 4
Paraffin	20 1		21 3	25 2
Mineral oil		23 1		
Vulcanized oil	51.3	64 6	52 5	47 9
Combined sulphur	13 8	13 5	3 6	3 1
Ash	0 1	0 1	0 7	0 1

Tables II, III, and IV contain analyses of foreign substitutes published by Dubosc in *Le Caoutchouc et la Gutta Percha*. Table V contains analyses of some American substitutes, made by the writer some time ago.

TABLE V

	A Per Cent	B Per Cent	C Per Cent	D Per Cent	E Per Cent
Acetone extract	5 50	23 02	10 5	49 4	25 5
Total sulphur	7 3			24 10	19 10
Free acid	None	0 005		None	None
Free sulphur	0 05			11 13	3 50
Solution in hot alcoholic potash	Complete				
Ash	7 85	15 20	3 0	0 70	0 12
$BaSO_4$	5 51	13 05			
MgO	2 19	1 10			
$CaCl_2$	0 27	0 08			

A, B, and C are white subs; D is black sub [illegible] rom [illegible]; E, is brown sub from rape oil.

Satisfactory samples of white sub will not show more than 15 per cent acetone extract and not over 5 per cent ash. Black and brown subs should not give over 25 per cent acetone extract nor ash higher than 3 per cent. Mineral acid should be absent in all cases.

In Europe substitutes are used much more extensively than in this country. American manufacturers, particularly tire companies, have not taken kindly to them. They hold that employment of sub is not only risky but productive of rather poor results. Another factor in this country is the huge supply of first-rate reclaimed rubbers many of which are of low sp. gr. No sensible manufacturer needs to use sub merely because he must cheapen this or that compound. He will use shoddy and produce, for the money, a higher quality stock than he could with sub. In Europe they formerly were not as successful with reclaiming practice and had to resort to substitutes, which they developed to a high degree.

2.– Asphaltic Materials

Under this head we will consider the following:

a. Coal Tar
b. Coal Tar Pitches
c. Asphalt Pitches
d. Mineral Rubber

Coal Tar

Coal tar, as such, finds a limited application, chiefly in reclaiming and in the compounding of exceedingly dry and hard shoddies. The amount used will never be more than 5 per cent but is usually 2 or 3 per cent based on the finished stock. It softens a stock and makes it more easily worked, for example, in a tube machine. The medium grade of tar which serves very well is about as thick as corn syrup, remains fluid as low as 10 deg. C. and should lose not more than 5 per cent when heated for 1 hr. at 100 deg. C. As indicated, it is only employed in very poor stocks for mechanical goods, as for example, stair pads, cheap heels, novelties, and cheap frictions.

Coal Tar and Asphalt Pitches

These two varieties of pitches, while coming from different sources, are very similar in their physical properties and use. Coal tar pitch is obtained by the distillation of coal tar and is marketed in many different grades which vary both in hardness and in melting point. Depending on the severity of the treatment it may vary from 37.5 deg. C. to 174 deg. C., and the constitution from a thick tar to a very hard, resinous mass. A piece of it may be easily chewed without any crumbling. Asphalt pitch may be either purified natural asphalt or the still residue from the distillation of asphalt base oils.

Both asphalt and coal tar pitches contain some mineral oil, and consequently their use beyond certain limits is dangerous because of the disintegrating action. The melting point varies from 100 to 130 deg. C. When added to rubber on the mills they soften and are easily dissolved. They make a batch soft, easily worked, and somewhat sticky. As a consequence they are much used in mechanicals for softening stocks which are to be run on a tubing machine, for frictions, and in cheap molded goods in which they function to a certain extent as binders. The quantity added will vary with conditions, but as a rule must not be greater than 15 per cent, otherwise there will be serious difficulty in milling the

stock which will stick to the rolls and be extremely hard to cut off. Eight to 10 per cent is the usual figure.

These pitches are soluble in benzole, carbon bisulfide, chloroform, carbon tetrachloride, about 50 per cent soluble in acetone, and about 70 per cent in naptha. The sulphur content may vary from 0 to 5 per cent, but is usually around 2 per cent or lower. Free carbon is much more important. It is liable to vary from 5 to 25 per cent but should be absent.

(d) Mineral Rubber

It is perhaps stretching a point to class coal tar and the pitches as rubber substitutes. Yet there is a good economic reason for it. If by means of certain pitches and the cheapest possible reclaim one can make a satisfactory stair tread, then there is certainly no reason for using fine para and high priced compounding materials. The policy is to suit the product to the purpose. But mineral rubber commonly known as MR is different. Coal tar and the pitches find their widest application in cheap mechanicals. MR can be used in all the high grade stocks except those which must be very white in color. It is by far the best substitute ever brought out. Stocks which must withstand the more severe conditions are actually benefited by the substitution of a small percentage of rubber by MR. That its merits are appreciated by the rubber trade is shown by its rise in price. In 1913 a good grade could be obtained for 1c per lb. By 1915 it was 2c and now it costs about 5c. When one considers that it is made from practically a waste material the rise in price is clearly due to the demand.

Mineral rubber, MR, is a hard, black, resin-like substance which readily passes into solid solution when added to rubber on the mixing rolls. The melting point by the cube method varies from 160-185 deg. C. When added on the mill, the heat of the rolls and the rubber (20 to 70 deg. C.) combined with the mastication it receives, softens it to the point where it is readily taken up and homogeneously distributed throughout the mass. When handled on a factory scale it is impossible to add more than 35 lb. of MR to a 100-lb. batch. The rubber absorbs it but becomes so soft and tacky that it cannot be cut off the mill. In regular practice 20 per cent is about the limit. More than this makes milling so difficult that the stock is likely to be overworked. In high grade stocks not more than 10 per cent should be used because of certain properties which will be discussed later. MR is essentially a bitumen. The first preparations were made by carefully combining gilsonite or grahamite with purified natural asphalt to give the desired physical properties. The next step in the development was to blend gilsonite or related bitumens with coal tar or asphaltic pitches. Following this, certain enterprising manufacturers discovered that they could produce an apparently good MR by cooking and blowing for a long time still residues of asphalt pitch. Today, much MR is made in this way and only two or three firms actually use any gilsonite. The processes in vogue are largely secret, but enough of the general procedure is known to realize that the operation is extremely simple. The important points are the selection of materials and the proportions in which they are combined, which must be learned by experiment. In order that the problems which confront both the maker and user of MR the nature and origin of bitumens will now be briefly discussed.

Asphalt: According to Engler the asphalts are derived from petroleum hydrocarbons through polymerization, free oxygen acting as a catalyser of the change. It has been shown that the formation of asphalt takes place more readily in the presence of air, yet the amount of oxygen absorbed is too small to account for the formation as oxidation.

The principal source of natural asphalt is Trinidad lake, which contains apparently an unlimited supply. According to Richardson[3] crude Trinidad asphalt contains 28 to 30 per cent water. In the dry state it has 56 per cent bitumen and 38 per cent mineral components. The remaining 6 per cent is water of hydration of the clay and some insoluble organic matter. The pure bitumen softens at 76 deg. C., melts at 83 deg. C., sp. gr. 1.032 at 25 deg. C., and contains 82.33 per cent carbon, 10.69 per cent hydrogen, 6.16 per cent sulphur, and .81 per cent nitrogen. It contains 63 per cent naphtha soluble malthenes of great viscosity and gummy consistency. The remainder is chiefly very hard and brittle asphaltenes. The Trinidad asphalt is mined with pick-axes, and somewhat purified by melting. Unless this is done very carefully by steam a part of the asphalt will be destroyed by overheating thus producing free carbon, which is contained by the poorer grades in amounts up to 11 per cent.

When this asphalt is to be used for paving no attempt is made to separate the high mineral content which is really valuable for this purpose. The molten asphalt is poured through a wide-mesh screen (1 cm.) to remove sticks and large stones. To completely purify it for use with rubber is rather expensive. Settling operations will do much, but the best way is by use of solvents, thinning the solution, settling, decanting, and filtering. The pure solution is then concentrated by evaporation and the solvent removed.

Residuum asphalts (artificial asphalts) are made from the still residues when asphalt base oils, such as those from Mexico, Texas, or California are distilled. With Pennsylvania, straight chain, oils paraffin is the end product, but with these oils, cyclic, asphalt is obtained. The asphaltic residue is then further treated by long cooking, during which air is passed through the melt. Artificial asphalt is really an accelerated natural asphalt. The nature of the product is dependent on

1. The duration of the cooking period. 2. The temperature. 3. Amount of air passed.

The product may be very soft or very hard, depending on the conditions.

Properties of Asphalts: They (both natural and artificial) are almost entirely soluble in carbon bisulphide and carbon tetrachloride; about 70 per cent soluble in 86 deg. B. naphtha; about 75 per cent soluble in ethyl ether; fixed carbon 0 to 15 per cent; melting points lay between 55 and 100 deg. C; loss on heating 5 hr. at 163 deg. varied from zero to 5 per cent. Sp. gr. at 15 deg. C. about 1.04; sulphur from .5 to 4 per cent. The asphalts consist to a very considerable extent of hydrocarbons not acted upon by sulphuric acid, that is, saturated hydrocarbons. Gilsonite on the other hand contains but a very small amount of such components.

[3]Petrol 7,1347

Data concerning this has been published by Richardson, as shown in table VI.

TABLE VI.

	Sp. Gr.	Per Cent Solution in Naphtha	Per Cent Saturated Hydrocarbons
Petroleum flux (Texas)	0 956	97 5	72 8
Residual pitch	1 089	65 0	33 1
Bermuda asphalt	1 082	62 2	24 4
Gilsonite (Utah)	1 044	47 7	5 5
Grahamite (Okla.)	1 171	0 4	0 3

Gilsonite and Grahamite: Grahamite is the result of metamorphic changes in gilsonite, which was in turn produced by metamorphic action on petroleum. The two materials present varying degrees of condensation, from the softest gilsonite which will flow in the sun to the hardest and most brittle grahamite which will not melt even at high temperatures.

The changes as metamorphism proceeds are indicated by the gradual decrease of the hydrocarbons and their derivatives which are soluble in naptha, from the amount present in the softest gilsonite to that in the hardest grahamite with a corresponding increase in the coke yielded by ignition. In Table VII we have data set forth by Richardson in illustration of this point:

TABLE VII.

Source	Flow of	Sp. Gr	Per Cent Solution in Naphtha	Per Cent Residual Coke
Residual:				
Texas residual petroleum		0.9524	88 0	6 5
Gilsonites:				
1. Utah softest	285	1 011	55 5	10 0
2. Utah		1 037	46 9	12.3
3. Utah	260		47 2	12.8
4. Utah	345	1.037	46 1	13.9
5. Utah hardest	Intumesces	1.057	24 5	16.7
Grahamites:				
Cuba, Bahia	Intumesces	1 157	38 8	40 0
Trinidad	Intumesces	1.156	14 8	40 0
West Virginia	Intumesces	1.130	9 4	36 8
Colorado	Intumesces	1 160	0 8	47 4
Oklahoma	Intumesces	1.184	0 4	51 4

Depending on the environment, petroleum was converted by metamorphic action into either gilsonite or natural asphalt. Grahamite, as previously mentioned, is derived from gilsonite, which is found chiefly in Mexico, Utah, California, Colorada, and at certan places in the Appalachian mountains. Grahamite is more abundant than gilsonite and is found in the same regions, in the southwest, etc.

Plasticity and Elasticity

Rubber has two important properties, plasticity and elasticity. Before vulcanization it is highly plastic with but little elasticity. After vulcanization it is highly elastic and very slightly plastic. MR is essentially a plastic substance and its introduction increases the plasticity of the resulting stock. This is not a desirable feature since it leads to a high set which may be explained as follows: If a thin piece of tube stock be cut and marked say with marks 2 in. apart and the piece stretched until the marks are 18 in. apart, then released; the distance between the marks will now be found to be greater than 2 in. This excess is known as set and depends on the plasticity of the rubber. The same thing is illustrated by the behavior of a pair of cheap overshoes. They fit well the first few times they are worn, but later develop a set. We say that they have stretched and no longer grip the shoes but slop up and down. This is entirely due to the plasticity of the stock of which the overshoes are made. Plasticity is the principal difficulty with MR. It is a valuable compounding ingredient. It decreases porosity and renders a stock easily worked. It may be substituted for a small per cent of the rubber content but its use is limited by the plasticity it develops in the stock. For high grade compounds not more than 10 per cent is desirable. In certain cheaper stocks such as mechanicals it may be added up to as much as 20 per cent. Used in small quantities it has little effect on the tensile strength and stretch, but as it is increased the set also increases. With larger amounts the physical properties are lowered. The effect when used in excess is to make a tough, snappy stock soft and dead feeling. To prevent confusion it should be mentioned that only a small percentage of rubber may be substituted by MR, never more than 4 per cent in a batch high in rubber, but it may be added to such a stock in much higher percentages in which case it functions as a light gravity filler.

The inspection of MR is extremely difficult. About the only test which is of value is melting point which is best made by the standard cube method. Much depends on the integrity of the manufacturer, and his ability to duplicate his first shipment, which should be given a thorough trial in several stocks and its ageing properties investigated.

As mentioned before, gilsonite is highly unsaturated, consequently MR's containing it are able to unite with sulphur when vulcanized. As a consequence only about one-half the MR added to the stock can be removed by acetone and chloroform extractions. The remainder is insoluble in the solvents ordinarily used in rubber analysis and consequently render a correct determination of the rubber content impossible. For this reason certain specification and analysis committees refuse to admit its use. The policy is rather a left handed one since MR really has certain desirable effects.

Vulcanization with sulphur seems to alter the nature of MR. A sample of MR rubber which contained gilsonite was examined by the writer not long ago. It was entirely soluble in chloroform and about 30 per cent soluble in acetone. A batch was made up containing 20 per cent. On extracting the cured stock 55 per cent of the MR was soluble in acetone, 5 per cent in chloroform, and the rest (40 per cent) insoluble in any solvent which would not attack rubber.

Resinous Substances

In this class are rosin oil, rosin, pitches, and crude turpentine. Their general effect is to soften and render tacky the stocks in which they are mixed. Rosin oil does not age well and should be used with great caution. Representative of the rosin pitches is Oregon balsam, which consists of rosin in turpentine. It is very sticky, and is sometimes used in quantities up to 1 per cent in high grade compounds which are to make good union with other stocks. It is also used in quantities as high as 5 per cent with cheap shoddies, where it acts to a certain extent as a binder. Crude turpentine which is true crude turpentine with the volatile oil removed is used for the same purpose, but is not as efficacious.

Greases and Waxes

Palm oil has long been used as a dope for softening stocks which do not flow smoothly on a calender. Vaseline is employed for somewhat the same purpose but is added directly to the batches during milling. The chief

waxes are Japan and paraffin. The former is really a grease and behaves as one. Paraffin is used quite a little in insulation. It is restricted in other work by the fact that when present over 2 per cent it comes to the surface and produces a dirty white scum.

Glue

There is hardly a rubber chemist who at some time or other has not played with this substance and the interesting combinations which can be prepared by mixing it with glycerine. Glue, glycerine, and vinegar are still used at times for multicopy pads and printer's rollers. But such articles are not strong and are hygroscopic. Many chemists have attempted to make something out of the insoluble product which results when glue is treated with potassium dichromate and alum or with formaldehyde. Many such ideas are patented but none have had any great success. Not long ago an English patent was granted for the manufacture of cheap tubing. The glue glycerine gel was to be fed through a die as in ordinary tube machine practice; the tube dropping directly into a solution of formaldehyde. There is no question that such a tube could be made, but it would have very little strength. Glue glycerine preparations do not work well with rubber. The behavior is similar to an attempt to mix water and oil.

Summary

In the foregoing the writer has pointed out certain factors and limitations which must be considered in studying the rubber substitute situation. Briefly they may be summarized as follows:

1. There is no real substitute for rubber.
2. Oil substitutes are not in great demand in this country because of the extensive use of reclaimed rubber and MR.
3. Certain pitches, greases, and waxes have been mentioned and their principal use stated.
4. Glue substitutes are yet in the experimental stage.

American Chemists' Defensive Measures Against Gas Attacks in France

The Gas Service a Special Arm of the American Expeditionary Forces—Enemy Now Sends Over Gas in Shells, Bombs, Clouds and Hand Grenades—Trenches and Dugouts Must Be Cleared After Attack

By ROBERT K. TOMLIN, Jr.
Special editorial representative in France for the McGraw-Hill engineering publications.

After one has been in France for some time and has had an opportunity of observing the varied character of the operations conducted under the general direction of the Chief Engineer of the American Expeditionary Forces, he begins to realize to what extent warfare on the vast scale of the present day is making insistent and continuous demands upon technical specialists. In previous articles in the McGraw-Hill engineering publications I have referred to a few of the almost infinite varieties of specialized work which our engineers are handling—road-building, railway yards, water terminals, quarrying of rock, light railway construction and operation, water supply at the front, map-making and the interpretation of aerial photographs. To these must be added the activities of our engineers and chemists in the gas service.

The men attached to this branch of the Chief Engineer's department are busy both in the field and in the laboratory. Their efforts, as explained to me at our General Headquarters recently by Col. F——, chief of the Gas Service, A.E.F. are being conducted along two major lines—offense and defense. On the matter of our offensive work it is considered advisable to say nothing at the present time. However, certain generalties regarding the German gas attacks and our defensive measures may be permitted, for most of what follows is pretty much of an old story here, although some of it may not be so well known on the other side of the Atlantic.

Few Cloud Gas Attacks Now

There has been for some time past, according to the Chief of the Gas Service, a very general trend away from the cloud gas attack on the part of the Germans. Practically all of the gas now comes over in the form of shells, fired either by long-range artillery pieces, or by trench mortars. There are a number of reasons to account for this change from the original form of attack. In the first place, the prevailing winds on the front have been against our enemy about 75 per cent. of the time. In the second, a comparatively light gas must be used in a cloud attack—a mixture generally of chlorine and phosgene—which is less effective than the heavier "mustard" gas used in shells. Then, too, the wind must be just right before a cloud attack can be launched, and the preparations for the attack in this form are necessarily elaborate, time-consuming, and hazardous, due to the danger of having gas containers punctured by rifle bullets or shells while in transit toward the front-line trenches. The effects of a light gas put over in a cloud are much less permanent than those of the heavy mustard gas.

In the days of the cloud attack, cylinders containing the liquefied gas were spaced along the front-line trenches at intervals so that there was available about 25 or 30 lb. of liquefied gas per foot of front. From these tanks pipe-lines of rubber composition or lead were extended over the parapet and forward a short distance. When the valves were opened it was generally the enemy's practice to begin a violent machine-gun fire to mask the hissing sound of the escaping gas. It is said that the Germans, in the early days of gas attack, started to build some distance behind their front a big manufac-

facturing plant and holder from which gas was to be piped underground to various points of use on the front lines. Allied aviators and artillery, however, by effective bombing and shelling, put a quietus on the central gas plant project.

Wind Velocities

Gas clouds have been launched by the Germans with a wind velocity as low as 2 miles per hour. Four miles per hour is considered fairly safe for the attacking party, but the most effective work can be done with the wind blowing at from 5 to 8 miles per hour. Gas attacks have been made on fronts varying from 1 to 5 miles. Even as far back as 12 miles from the front their effects have been great enough to demand the wearing of masks. The lightest gases used in clouds did not can do damage 10 or 12 miles back of its initial point of discharge.

Being heavier than air the gas will follow the slope of the ground and, if atmospheric conditions are favorable, will sweep down a valley like the flow of a river. The effects of gas are generally confined to points not higher than 30 feet above the general level of the ground. A gas cloud passing down a valley may, therefore, be largely avoided if there are any high points, such as knolls, which can be climbed. Rain or mist has no appreciable influence on the effectiveness of a gas cloud attack.

Gas Shells

When the use of gas in shells was first tried the enemy used just enough explosive to vaporize the charge

AMERICAN SOLDIERS WEARING NEW GAS MASKS IN FRANCE
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produce an effect which lasted more than about 20 minutes; that is, with a 4-mile wind and a mixture of phosgene and chlorine, the all-clear signal could be given half an hour after the cloud had passed over a specific point in the open near the Front, but in dugouts there was danger during a period of 3 hours or more, unless a fire could be built inside to ventilate them, in which case the air became safe to breathe in 15 or 20 minutes. The cloud attack was sometimes launched in one continuous operation and at other times in waves, with a half hour or even greater interval between successive clouds. In answer to a question regarding the lateral spread of a gas cloud, the Chief of the Gas Service explained that with a low wind velocity and a high concentration of light gas, the edges of the advancing cloud would become too dilute to do much damage before the cloud attained twice its original width. If launched on a wide front, however, a gas cloud of high concentration of liquefied gas. Several different kinds of gas were employed in the early days of gas shelling before the use of "mustard gas" became prevalent. The noise of the detonation of these lightly charged shells was much less than that of a high explosive shell and it was easy to differentiate between the two. Sometimes, in fact, the low explosive gas shells were mistaken for "duds" (shells which fail to explode properly). Now, however, the amount of the explosive charge in gas shells is being increased, so that almost every bursting shell must be regarded with suspicion so far as gas is concerned.

"Mustard gas," which has been used by the enemy so extensively for months past, is an organic compound containing chlorine and sulphur, known as dichlorethylsulphide. It is employed in shells of all calibers up to 8-in. It produces severe burns if it comes in contact with the body and is painful to the

eyes. Food eaten after having been subjected to the influence of mustard gas has been known to burn the lining of the stomach. It is a very heavy gas and has a fairly high boiling point, 400 deg. Fahr., a fact that makes it unsuitable for cloud attack, for it must be vaporized by an explosion. Gas has killed men as far back at 12 miles from the front. Mustard gas will linger a long time in the vicinity of shrubbery and woods and, forming pockets in shell craters, contaminates the earth, which often must be treated with chloride of lime if there is any chance of men coming in contact with it. With a favoring wind a mustard gas shell can be shot over troops and dropped only 500 yd. ahead of them without placing them in danger.

Gas Specialists Instruct Troops

One of the functions of the Gas Service of the American Forces, so far as defensive work is concerned, is to equip our troops with the means of combating gas attacks and to instruct them in safety measures. With this object in view men specially trained in gas work are assigned to the various units in the field and act as instructors in all matters relating to defense against this form of attack. For the guidance of officers the Gas Service has given much valuable advice on the detection of gas and what to do in case of attack.

Nowadays gas-shell bombardment is to be expected everywhere within the range of artillery—in front line trenches, communication trenches, camps, billets, etc. The enemy's object, of course, is to catch bodies of men unprotected against gas and to develop a high concentration by heavy bombardment. The practice now is either to mix up the gas and the high-explosive shells, or to use gas shells containing a fairly large charge of explosive. This makes it very difficult to detect the beginning of a gas bombardment, especially as the mustard gas has a very slight odor and does not produce an immediate effect on the eyes and lungs. After several hours, however, it causes the eyelids to swell, results in intense pain and loss of sight for from one to four weeks, and, if inhaled, its attack on the lungs soon produces death.

Two Forms of Mask

The instructors from the Gas Service train our line officers in the proper use of the gas-mask and box-respirator, and this instruction is passed on by the latter to the men in the ranks. The so-called mask is the one used by the French armies and is a face-covering with a pocket containing chemicals through which the breath is drawn and expelled. With the mask one breathes through the nose. The box-respirator, the standard for the English armies, is a more elaborate affair, comprising a face-covering, nose-clip, chemical box with check valves and a flexible tube extending from the chemical box into the mouth, the teeth closing on a rubber strip something like that of a foot-ball nose-guard. Breathing must be done through the mouth, as the nostrils are closed by the spring-clip. The box-respirator is considered the more reliable of the two forms of equipment. It proved to be well adapted to our white troops, but when our negro regiments attempted to use it they found the standard clip entirely unsuited for their broad, flat noses. A detail of the Gas Service, therefore, was assigned the job of designing a special nose-clip for negroes.

In the American Forces a box-respirator or a mask must be carried within 12 miles of the front; the choice is optional. But regulations prescribe that the box-respirator must be worn within the 5-mile zone and that

U. S. MARINES IN TRAINING IN FRANCE WEARING FRENCH MASKS
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U. S. MARINES IN FRANCE TRAINING WITH FRENCH MASKS, ENTERING A GAS LADEN CHAMBER
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a man must be clean-shaven, for a heavy growth of beard prevents close contact between the skin and the face-piece, thus allowing gas to leak in. Within the 2-mile zone, the mask and box-respirator must be worn, the latter in the "alert" position—flap open.

Protection of Dugouts

Since all gas used in attack is heavier than air it collects in low spots, such as dugouts and cellars, unless these are protected. Our gas specialists have outlined the best methods of such protection. In the case of a dugout the entrance is to be covered with blankets nailed across the top of the doorway and attached along the bottom edge to a 1-in. x 3-in. plank upon which the blanket may be rolled up. Sometimes these blanket stops are single and sometimes in pairs, the latter forming a sort of entrance lock to the dugout. When the gas warning is sounded these blankets are unrolled and sprayed with water or a mixture of glycerine and water to ensure air tightness.

After a gas attack trenches and dugouts must be cleared. For the trenches a canvas anti-gas "fan," which has the general form of a small snow-shovel, has been devised. It has a short wooden handle and the canvas blade is braced with cane strips; the end and sides of the shovel blade are in the form of hinged strips, the latter making contact with the sides of a trench. With this fan, gas which has collected in a trench is literally shoveled out. The fan is first brought down with a slapping motion and then flicked upward over the right shoulder of the man who is operating it, gas being thrown up over the parapet.

In clearing dugouts ventilation resulting from the building of a fire within them is considered the best method. In general 1 lb. of dry wood per 100 cu.ft. of air space is sufficient. The fire should be kept burning at least 15 minutes. There are also special mechanical fans with filter bottoms for clearing dugouts.

Among other duties connected with the defense against gas are wind observations, at regular intervals, and the collection of samples of gas during an attack. The field work, however, represents only part of the operations of the Gas Service. A staff of chemists is engaged in the laboratory work necessary for the investigation of the countless problems involved.

Paris, France.

France Needs Agricultural Chemicals

According to Vice Consul A. D. Beeler of Bordeaux the proper care of the vineyards requires the application many times during the season of certain solutions of chemicals which have been employed widely for a number of years. These chemicals include copper sulphate crystals, sulphate of iron, sulphur of both triturate and sublimate forms free from sulphuric acid and various special fertilizers for the soils. Some cultivators apply first the sulphate of iron in March as a preliminary measure against the diseases of the vine and in order to clean the stalks. The next application is usually a wash of sulphur, which remains on the vines until after the leafing period, late in April, when the spraying with solutions of sulphate of copper is begun. With the growth of the foliage come new dangers in the nature of diseases, mildew, brack rot, scale, and caterpillars, all of which increase the necessity for the continued spraying of this solution of copper sulphate throughout the growing season until a very short time before the harvests or vintages in late September or early October. Local manufacturers are unable to supply the demand owing to their activities in making munitions, while importation from England is inadequate to supply the deficiency and sulphur importations from Italy are largely curtailed. Copper sulphate crystals are therefore selling in the local markets at from 18 to 21 cents per pound, and the available sulphur supply at from 11 to 13 cents per pound, prices never before known in that region. Under these conditions, it is thought that a large quantity of American chemicals could be profitably exported. The present tariff per 100 lb. is 26c. for $CuSO_4$; 11c. for $FeSO_4$; 26c. for sulphur.

Italian Chemical Manufacturing.—Many chemical manufacturing concerns have been started in Italy since the war. The most noteworthy of these installations are the Solvay soda works at Castiglioncello, and Piedimulera, the explosive plants centering around Cengio, and the ammonia and nitric acid plants at Legnano. In many places the distillation of tar and the production of benzol is under way, while various Italian factories have begun making sulphur dyes and pharmaceuticals.—*Commerce Reports.*

Analysis of Natural Gases*

THE analysis of natural gas by the methods given for the other fuel gases described herein is not very satisfactory. If but little, say 10 cc., of the methane and ethane are exploded with oxygen, any error in reading is multiplied many times. Again on combustion of a large quantity with oxygen, the resultant gas is nearly pure carbon dioxide and, its solubility in water varying with its percentage, consequently a relatively large quantity is dissolved. The second contraction, i.e., on absorption of carbon dioxide, being low, the result is that the sum of the methane and ethane obtained by calculation is over 100, and the nitrogen a minus quantity. To overcome these defects, use is made of the following method in which the contraction on explosion and on absorption of the carbon dioxide is treated as one known factor and the oxygen entering into combination the other factor.

Percentage of Oxygen in Commercial Oxygen

Commercially pure oxygen is used instead of the oxygen and nitrogen mixture of previous methods. This practice is necessary on account of the great amount of oxygen required for combustion. The determination of the percentage of oxygen is made by exploding a large quantity of it with hydrogen and noting the resultant contraction, of which one-third equals the oxygen. The determination is best accomplished in the following manner: about 100 cc. of pure hydrogen are forced into the burette, the capillary is filled with water from the explosion pipette, a reading is taken, and the gas is forced into the explosion pipette until the water level is at zero; about 100 cc. more hydrogen are introduced, and a reading is taken; the gas is then forced into the explosion pipette until the water level is again at zero. About 60-65 cc. oxygen are then added, a reading is taken, and 15 cc. portions are successively introduced into the explosion pipette and exploded, the gases being well mixed before the last explosion. After the final explosion, the residue is drawn over, the capillary being filled with water, and a reading is taken. One-third of the contraction is oxygen, from which the percentage can be calculated.

Determination of Carbon Dioxide

Exactly 100 cc. are forced into the burette from the sampling tube, as described previously. A reading is taken, and the gas is passed through the potassium hydroxide pipette for the absorption of carbon dioxide, then returned to the burette, and the capillary filled with water from the explosion pipette. A reading is taken; the contraction in volume is the percentage of carbon dioxide.

Determination of Illuminants

The use of fuming sulphuric acid is not advisable here as it absorbs the higher members of the paraffine group. In its place is substituted a pipette containing a 1 per cent solution of palladium chloride. The gas is passed three times through this solution and returned to the burette, the contraction being illuminants, thylene and its homologues. The contraction in volume would also include hydrogen and carbon monoxide, if present; however, the rate of absorption of these gases is comparatively slow. They are generally absent, and their absence is proved by the method described later. One passage of natural gas through fuming sulphuric acid gives about the same contraction as the method described herein, but repeated passages take out more and more of the paraffine. No definite result is obtained.

Determination of Oxygen

After absorption of illuminants, the gas is passed into the phosphorus pipette for the absorption of oxygen, and while it is there, the requisite amount of oxygen is measured in the burette and transferred to the explosion pipette. The gas in the phosphorus pipette is then returned to the burette, and the contraction due to absorption of oxygen is noted.

Determination of Methane and Ethane

The gas residue consists, besides the small quantity of nitrogen, of methane, ethane and perhaps other higher homologues. It is impossible by any method to determine more than two gases of the paraffine group by combustion, and the gases are assumed to consist of methane and ethane. No error is introduced by this assumption, as proven later.

While the gas is in the phosphorus pipette as described above, oxygen is drawn into the burette to its capacity, the capillary is filled with water, and a reading is taken. The gas is then forced into the explosion pipette until the water is at the zero mark, the capillary containing gas. The right hand capillary tube is flushed with water, and 50 cc. of air are drawn into the burette and measured; about 15 cc. oxygen (sufficient to make the total 122 cc.) are then added, and the gas is forced into the explosion pipette. The right hand capillary is flushed out, and the gas in the phosphorus pipette is drawn into the burette and measured, as described under Determination of Oxygen. One-half the residue is discarded or reserved in the phosphorus pipette. About 10 cc. of the half reserved for analysis are forced into the explosion pipette and exploded. This operation is repeated with successive portions of the gas until the last is added, when the gases are thoroughly mixed before explosion. The resultant gas is very rich in carbon dioxide, which, if the gas were passed into the burette, might be absorbed by the water. Later on this dissolved carbon dioxide may be given off by the water. Therefore, a compressor is placed on the rubber tubing from the burette to the bottle, and the gas in the explosion pipette is forced to bubble through the potassium hydroxide pipette by raising the bottle connected to the explosion pipette. After the gas has been passed several times it is transferred to the burette, and a reading is taken. The sum of the diluted oxygen added and the gas residue taken for explosion, minus the volume remaining after the absorption of carbon dioxide, is Contraction "A." Hydrogen is then added to the capacity of the burette, a reading is taken, and the gases are passed into the explosion pipette, well mixed and exploded. The residue is passed into the burette and measured; the decrease in volume is Contraction "C."

From the above contractions ("A" and "C") and from

*From the second edition of the U. S. Steel Coproration's "Methods for the Technical Sampling and Analysis of Gases."

a knowledge of the amount of oxygen in the commercial oxygen, the methane and ethane may be calculated. The reactions of burning methane and ethane are as follows:

$$CH_4 + 2O_2 = CO_2 + 2H_2O.$$
$$2C_2H_6 + 7O_2 = 4CO_2 + 6H_2O$$

From these reactions it is seen that the total contraction on combustion and absorption of methane and ethane are 3 and 9 2 times the volume of the respective gases; or that "A" = $3CH_4 + 9\ 2C_2H_6$. Likewise the oxygen consumed (Oc) is 2 and 7 2 times the volume of the respective gases; or Oc = $2CH_4 + 7\ 2C_2H_6$. Also it is evident that the oxygen consumed equals the oxygen added (Oa) minus the oxygen entering the second explosion, which is 1 C. or Oc = 1 3C.

From these equations the following formulæ are derived:

$$CH_4 = \tfrac{2}{3}\ A + C - 3Oa.$$
$$C_2H_6 = (A + 1\ 3C - 0a) - CH_4.$$

Example—Data

BURETTE READINGS

Purity of Oxygen

Hydrogen added	0 0 99 0	99 0 Hydrogen added
Hydrogen added	0 0 96 8	96 8 Hydrogen added
Commercial Oxygen added	0 0	61 8 Commercial Oxygen added
Explosion	61 8	257 6 Total volume
	77 0	180 6 Contraction
		77 0 Residue
		60 2 Contraction or Oxygen

60 2 — 61 8 = 97 4% Oxygen in Commercial Oxygen

	Gas Analysis	
	100 0	
Potassium Hydroxide	99 8	0 2% Carbon Dioxide
Palladium Chloride	99 4	0 4% Illuminants
Stick Phosphorus	99 4	0 0% Oxygen
	49 7	½ Residue

	Gas Analysis		Oxygen
Commercial Oxygen	0 0 99 4	99 4 Commercial Oxygen	96 82
Air	0 0 50 0	50 0 Air	10 45
Commercial Oxygen	15 0	15 0 Commercial Oxygen	14 61
	65 0		121 88
		49 7 ½ Residue	
		214 1 Total volume	
Explosion and Absorption		53 9 Residue	
	53 9	160 2 Contraction A	
Hydrogen added	98 4		
Explosion	67 7	30 7 Contraction C	

Calculations

160 2 × 7	Contraction A
3/1121 4	
373 8 30 7	⅓ Contraction A Contraction C
404 5 365 64	3 × Oxygen added
38 86	Methane
160 2 10 23	Contraction A ⅓ Contraction C
170 43 121 88	Oxygen added
48 55 38 86	Total Combustible Methane
9 69	Ethane.

DETERMINATION OF HYDROGEN AND CARBON MONOXIDE

These gases are generally absent. If present, they reduce palladium chloride somewhat slowly, water and carbon dioxide being formed. If the diminution in volume caused by the passage of the gas through palladium chloride is considerable, the presence of hydrogen or carbon monoxide would be indicated, in which case their determination is advisable. For this purpose, the apparatus for supplying hydrogen is disconnected, and a palladium tube is connected to the end of the gas apparatus—the other end of the palladium tube is connected to an absorption pipette containing water. The palladium tube is immersed in a beaker of water at 90-100 degrees C., and oxygen is passed through the tube to oxidize any hydrogen present. The water is drawn to a specified point in the stem of the absorption pipette, and the capillary tube of the apparatus is filled with water from the explosion pipette. Fifty cc. of natural gas are then introduced into the burette and measured, the carbon dioxide is removed, and the gas is passed through fuming sulphuric acid. About 10 cc. of oxygen are added, and a reading is taken. The gases are then passed back and forth through the palladium tube, which is immersed in hot water at first and then in cold water to cool the gas. The gas is finally brought back into the burette, the water in the pipett ebeing at the previous level, and a reading is taken. The decrease in volume is noted as Contraction "a." The gases are then passed into potassium hydroxide, drawn back and measured; the diminution in volume is Contraction "b." From a study of the contractions formed in the combustion of carbon monoxide and hydrogen, it is seen that

$$CO = b;\ H_2 = (2a - b)\ 3.$$

ERROR IN ASSUMING THE GAS TO BE METHANE AND ETHANE

The basis of the determination is in reality the volume of combustible gas (equal to A—Oxygen consumed) and the oxygen necessary for combustion (Oxygen consumed = Oxygen added — C.). Both are accurately determined, consequently the combustibles present and the amount of air necessary for their combustion as calculated from the analysis is correct. The carbon dioxide formed on combustion has not been determined but can be calculated for any and all paraffines which have the general formula C_nH_{2n+2}. If n represents the number of carbon atoms in the molecule, and p the total volume of paraffines, then, by reasoning analogous to that given when the formula were derived, np equals (Oxygen consumed — ½ A). But np equals the carbon dioxide and is independent of any particular paraffines that may be assumed to be present, therefore, the carbon dioxide formed on the combustion of the gas, as calculated from the analysis, is correct. As regards the heat value calculated from the analysis, Thomson has shown that the heat value of a paraffine is equal to K + nD, where K and D are constant factors. The heating value of the combined portions of natural gas then is (K + nD) p or Kp + Dnp. It has been shown that p and np are correct, depending upon the factors A, C and Oc. Therefore, the heating value of natural gas as calculated from the analysis is correct.

Charcoal Precipitation of Aurocyanide

A Description of the New Moore-Edmands Process With Discussion of the Underlying Theories

By A. W. Allen

THE use of charcoal as a precipitant of gold from aurocyanide solution has never reached the point of importance where it might be considered as a serious rival to zinc. Lump charcoal was used in the early stages of the cyanide process on a commercial scale in Victoria, Australia; and has been adopted to a small extent elsewhere but without success. The only exception to this statement may be found in the case where gold from waste solution discharged from a cyanide plant to reduce fouling, or to prevent undue accumulation of liquor, is recovered by this method. Appreciable quantities of gold may also be saved, by the use of charcoal, from decanted solution from slime tailing dams, or where the seepage from tailing-filled stopes carries small amounts of dissolved metal. In such instances the results may be termed satisfactory only insomuch as an amount of gold is recovered that would otherwise be lost. Effort is seldom made to effect a complete saving, the equipment is usually neglected during the month and attention only paid to it when the urgent need of an addition to the gold yield is in evidence.

On a commercial scale the substitution of lump charcoal for zinc could not be considered satisfactory from any standpoint. A large amount of charcoal is needed to recover a small amount of gold. The product, even after burning, is bulky; and the gold content of the ash to be smelted is exceedingly low. The efficiency of the process, unless an enormous amount of charcoal is used, is unsatisfactory. No progress in the adaptation of charcoal as a means of recovering gold from cyanide solution has been made for many years; and its use in this connection has been considered as unfeasible as the cyanide process itself was viewed before MacArthur and Forrest invented a method of procedure capable of practical application.

The Work of Moore and Edmands

A noteworthy advance is now due to the efforts and ingenuity of K. Byron Moore and H. R. Edmands who have resurrected the question and, after exhaustive laboratory experiments, have perfected a system of precipitation with charcoal slime which apparently leaves little to be desired. The method has been finally adopted at the Yuanmi mine, Western Australia, and is also being practised in South Africa. In the former case a foul and complicated cyanide solution containing antimony and arsenic is successfully freed of its gold. With zinc precipitation there was trouble and loss from high tail solution, the cost of zinc was considerable, and, even after extensive refining, the bullion was comparatively low grade. By the adoption of the new charcoal method the effluent from the extractors may now be reduced to contain but a trace of gold. The bullion, after simple smelting, is valued at about $20 per oz., as compared with about $17 per oz. for a similar product after zinc precipitation. The saving in the cost of recovery of the gold is about 25 cents per ton of ore treated.

After a year of operation a statement of result was published by H. G. Walton.[1] No fouling agent similar to the double zinc cyanide appears in the solution; and such a result would automatically effect a saving in cyanide consequent on a permissible reduction of cyanide strength in the solution. No figures are available in this connection, but in a later publication by H. R. Edmands[2] it is to be noted from comparative results of the use of zinc dust and charcoal that the necessary cyanide strength in the case of zinc was five times as much as when charcoal was used.

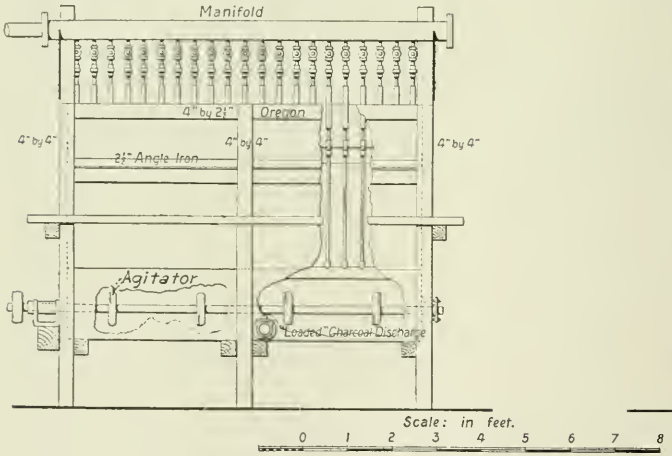


FIG. 1. FRONT ELEVATION

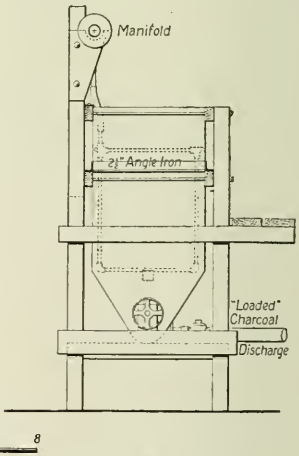


FIG. 2. END ELEVATION

MOORE-EDMANDS EXTRACTOR

[1] Report of the Department of Mines of West Australia, 1916.
[2] Bull. Inst. Min. & Met., London, March, 1918.

The principal features of the new Moore-Edmands process are as follows:

Preparation of Charcoal

The charcoal used is water-quenched when red-hot, washed, and wet ground in a small ball-mill to as fine a product as possible.

Moore-Edmands Extractor

A special form of extractor is used consisting of a miniature vacuum-filter of (what is known outside Australia as) the Butters type. The suspended frames are 2 ft. 3 in. x 2 ft. 9 in., and there are 21 to each extractor. The filter media are, respectively, coconut matting as a support, filter canvas, and an outer protective layer of calico. The extractor is shown in Figs. 1 and 2 and contains four agitators in the bottom of the hopper, attached to a horizontal shaft.

Method of Operation

Solution and charcoal pulp are pumped to an extractor and the vacuum started as soon as the leaves are properly submerged. Fresh solution is added concurrently with the formation and maintenance of cake, and the supply of liquor is such that a continuous stream passes through the charcoal. The propellers are kept in operation and percolation continued for 24 hours, or some other pre-determined time. The vacuum is then released, the charcoal cakes dropped to the hopper bottom of the extractor, emulsified, and re-formed on the filter leaves by the application of vacuum. This cycle of operations is continued at intervals as long as the charcoal possesses sufficient activity to precipitate the gold. The extractors are worked in series, the one whose cakes are approaching gold saturation receiving the richest solution, the tailing from this going to the second extractor, and being finally impoverished by contact with fresh charcoal.

Washing of Charcoal-Gold Precipitate

The final emulsified charcoal pulp, loaded with gold, is delivered to a clean-up press, washed, and dried with compressed air.

Calcining

Burning of the charcoal is carried out in braziers, 18 in. x 18 in. x 18 in., and made of ½-in. aperture stout wire screening. The operation is carried out in a locked steel chamber and takes about 48 hours.

Smelting

The flux adopted is as follows:

Precipitate	100 parts
Borax	40 to 50 "
Sand	50 "
Salt	10 "

Plain graphite crucibles are used and have a long life.

Fineness of Bullion

A comparison of results with charcoal and zinc precipitation is as follows:

	Charcoal	Zinc
Gold	954.4 fine	825.2 fine
Silver	7.0	21.9
Base	38.6	152.9

Weight of Charcoal Required

Walton states that 1 ton of charcoal will precipitate 770 oz. of gold by this method, and that the weight of calcined ash is about one-third of the original weight of the charcoal. Edmands' gives the percentage of gold in the calcined ash as from 10 to 14 per cent. The enormous increase in the precipitating power of charcoal by fine grinding is indicated by the fact that, by the old method of percolation through extractor boxes, 5 tons of charcoal was needed to precipitate about 700 oz. of gold.

The charcoal used at the Yuanmi mine is an otherwise waste product from producer-gas manufacture. The wood used is locally known as mulga scrub and is a variety of the acacia family which includes several wattles indigenous to Australia. It is possible that the character of the wood, which in some species contains a considerable amount of tannin, has a favorable effect on the final result. Different woods have widely different precipitating values when made into charcoal and used for the recovery of gold from cyanide solutions.

The sole drawback to the method appears to be the amount of material to be smelted. The actual smelting entails no difficulties and there is little corrosion of crucible. The latter might even be reduced by an alternative flux. In medium- or large-sized plants such low-grade precipitate is best smelted in large tilting furnaces—an arrangement permitting the periodic pouring of slag only, the gold being allowed to accumulate in the bottom of the crucible, where it refines. This method minimizes the temporary loss by shotting met with when small charges of gold are poured through a large bulk of cooling slag. The furnace also acts as a safe during night operations, when there is less available supervision, and when minimum handling of bullion is advisable.

Theory of Charcoal Precipitation

The various theories propounded to account for the action are as follows:

Occluded Oxygen Theory.—It has been suggested that an insoluble gold cyanide and sodium cyanate is formed.

Electro-Deposition Theory.—This theory assumes that gold is deposited as metal as the result of electrical action. It is disproved by the fact that there is no corresponding liberation of cyanide during precipitation.

Carbon Monoxide Theory.—The assumption that a chemical action takes place between the occluded carbon monoxide gas and the aurocyanide whereby a carbonyl aurocyanide, or other analagous compound, is formed has been widely accepted. Criticism of this theory must be mainly constructive and in opposition. All the asumptions are hypothetical and no parallel action is known with charcoal.

Adsorption.—The theory that the precipitation is due to a simple adsorption of aurocyanide—$KAu(CN)_2$—is supported by the following facts:

1. The loss of cyanide, by titration, agrees with theoretical considerations.
2. Precipitation efficiency varies inversely with the concentration of the solution, and a true absorption curve may be plotted from actual results.
3. Precipitation is proportionate to surface exposed, finer grinding giving better results.

4. Methods of preparation of the charcoal which drive off occluded gas (quenching when red-hot and wet grinding), and so increase surface energy of the charcoal, result in a more favorable action.
5. The addition of acid accelerates precipitation whereas alkali retards it. This is a parallel instance of the obstructive effects of hydroxyl as compared with hydrogen ions as demonstrated by Lachs and Michaelis[5] in connection with the adsorption of an aqueous solution of potassium chloride by charcoal.
6. The adsorbed gold compound is insoluble in ordinary solvents although released by the addition of a solution of different surface tension, such as a soluble sulphide—a parallel to the case where picric acid adsorbed on platinum may be released by alcohol, although unaffected by water, its natural solvent.

New York, N. Y.

Tariff Commission Conference on Antimony, Quicksilver and Tungsten

The United States Tariff Commission is now engaged in the systematic assembly of information on the various industries of the country, with a view to presenting it in well-digested form for the guidance of Congress. The Commission is receiving valuable assistance from manufacturers, merchants, consumers, and the public, and this co-operation is being continually extended and strengthened. Engineering societies and Government bureaus are consulted as the work progresses. Attention will be given to labor conditions.

A conference will be held at San Francisco in the Assembly Room of the Chamber of Commerce during the week of June 24th on antimony, quicksilver and tungsten ores and products, to which the producers, importers and consumers interested in these metals from all parts of the country will be invited. The conference is for the purpose of securing information in regard to disturbances and changes in these American industries. The topics to be discussed fall under three heads:

(1) The condition of the American industry before the war, in relation to foreign competition;
(2) The effect of the war on the industry;
(3) Competition with foreign producers after the war.

The conference will take the form of an inquiry into the effect of the war upon production, markets, plant expansion, increase in cost of materials and wages since 1914, and post-war competition—all of which will be considered in their bearing upon the tariff. Imports and exports, relative foreign and domestic costs of production of metals and products, and the adequacy of American ore deposits for domestic needs will be among the subjects discussed.

A separate hearing on tungsten will be held in Denver, Colorado, on Monday, June 17. This meeting will be opened at 10 a.m. in the United States District Court Room at the new Post-Office Building, and the proceedings will be of the same general nature as at the California conference. At San Francisco, the hearing on antimony is to be called at 10 a.m., Monday, June 24; quicksilver Wednesday, June 26; tungsten Friday, June 28.

The Commission hopes that the meeting may fairly represent the various interests involved. General notice and invitation is being sent to those concerned.

[5]Zeit Electrochemie, 1911.

Determining Copper Minerals in Partly Oxidized Ores

By Felix Cremer

THE article of Charles E. Van Barneveld and Edmund S. Leaver[1] on the determination of so-called oxides in mixed ores, gives me an opportunity to state my own ideas on the subject and review a few facts connected with my work in that direction. In January, 1917, I took charge of the first experimental work to be conducted by the Andes Copper Mining Company at Potrerillos, Chile, for the study of the best method of treating the ore from their large copper deposit. This consists of a great mass of eruptive rock, variously called, syenite, rhyolite and porphyry, ejected through a limerock formation and greatly altered in texture and composition in most places, thus giving the whole a very complex and heterogeneous structure. One of the features of the decomposition of these rocks has been the percolation of copper-carrying solutions, originating with some of the rocks of a primary character, and resulting in the deposition of new copper minerals in local deposits of irregular shape, size, structure, composition and richness. While in some places the processes of repeated solution and precipitation resulted in deposits of very high-grade ore, of more or less limited extent, in other places the elementary rocks do not seem to carry more than traces of copper.

Some of the richest ore, near the surface, has been extracted in the past by the natives, but this ceased to be profitable where it became necessary to do much dead work to find the rich ore in so much low-grade material. Therefore, nothing remained but to mine the ore by a more or less selective process on a large scale, the problem being to conduct the operations in such a way that a sufficiently low cost would allow portions of the deposit to be handled in bulk, i.e., without any attempt at descriminating, locally, between rich and poor ore, and then to find these portions and outline their boundaries.

Copper Minerals in Potrerillos Deposit

The principal copper minerals identified in this deposit are chalcorite, chalcopyrite, some bornite and covellite, chrysocolla, some malachite, atacamite, brochantite, cuprite and native copper; but it is important to observe, for the possible treatment of the oxidized ore by film-sulphidizing and flotation, that little of the silicates of copper, constituting the main portion of the oxidized minerals, appear strictly as chrysocolla, but simply as copper-impregnated quartz, the copper being preserved in all proportions, from a slight greenish stain to the correct percentage corresponding to the mineral chrysocolla.

The relative amounts of sulphide and oxides in the deposit, estimated from the reports of the drill men—these again basing their opinion on the evidence from panned drill-hole samples—is about half and half; but, as this process of arriving at the facts is not as precise as might be desired, the figure is subject to more or less correction. This, however, is not as simple a matter as it would seem at first glance, for reasons which will become apparent from what follows:

[1]This journal, Feb. 18, 1918, p. 203.

At the time I commenced to work on this matter, two methods of determining the so-called oxide copper, namely, were known to be in use, heating the sample with a 5 per cent solution of sulphuric acid, the one method calling for a 24-hour treatment at room temperature and the other for one-hour treatment near the boiling point. The ammonia method, mentioned by Van Barneveld and Leaver, had not come to our knowledge, nor would have inspired much faith in its utility on chemical considerations, and does not seem to be much in use. The other two had been the classical methods for a number of years in all the leading American copper mines, at home and abroad, where the grave objections to them did not seem to have been fully realized, as no serious attempt was made to devise a better method.

Test of Sulphuric Acid Method

My first step, in putting the H_2SO_4 method to a test, was to try it on a high-grade oxidized ore, carrying about 20 per cent cuprite and 10 per cent chrysocolla, which showed at a glance that the copper from the cuprite was not all dissolved, but that part of it remained insoluble as metallic copper. This would naturally appear in the assay returns as sulphide copper, in the same manner as all native copper would appear in the same column.

When this weakness of the method was discovered, an attempt was made to find a solvent for this metallic copper. While experimenting along that line it was noticed, under the microscope, that few if any samples delivered to the laboratory were free of metallic iron, which was then identified also by ocular inspection of the pannings from the samples. In some instances these carried practically nothing but iron, when the drillers had attempted to straighten out a crooked hole by filling the bottom up with tin-cans and similar material. Of course this added another error to the determination, operating in the same sense as the two first mentioned, by precipitating a certain amount of copper from that taken into solution by the acid.

Against these three sources of error, all tending to show higher sulphides at the expense of the oxides, there is the solubility of the sulphides by sulphuric acid mentioned in the article referred to, which escaped our notice as the method was soon discarded after its defects had become known. This probably explains some of the erratic returns obtained previously which could not be accounted for by the then known facts. In regard to this solubility of the sulphides in dilute H_2SO_4, I am not quite convinced that this is due to the direct action of the reagent. In some cases of a similar nature we have traced the apparent attack of sulphuric acid on sulphides to the presence of chlorides and nitrates in the ore, and it might not be amiss to test this point by repeating Messrs. Van Barneveld and Leaver's experiments on an ore thoroughly leached with water previous to the addition of the acid, which, of course, must also be free of chlorine and nitric acid.

Unreliability of Sulphuric Acid Method

When it began to be realized how utterly unreliable the H_2SO_4 method was for the determination of oxide copper, steps were taken to find a better method. For a while our hopes were placed on hydrogen peroxide, which, under the microscope had been found to dissolve the metallic copper in dilute H_2SO_4, and proved afterwards to attack natural sulphides only slightly. Artificial sulphides, however, i.e., those precipitated from copper solutions by H_2S, were freely attacked, and since this method would not have solved the metallic-iron difficulty anyhow, it was soon abandoned.

On the other hand, phosphoric acid, which also proved a good solvent for all carbonates and silicates, did not attack the sulphides (natural or artificial), nor were its copper salts affected by metallic iron, but neither it did not dissolve metallic copper. In searching, therefore, for a solvent for this, it was found in ammonium chloride which dissolves metallic copper more readily than any other reagent known to us. Thus a combination of phosphoric acid and ammonium chloride suggested itself and was tried on a variety of our ores, with results that seem to place the method on a par, at least, with the sodium tartrate method of Hunt & Thurston and the sulphur dioxide method of Van Barneveld and Leaver. The latter method was not known to us before my recent separation from the Andes Copper Mining Co., and therefore could not be tested, but with the tartrate and phosphoric acid methods a number of parallel determinations were made which seem to indicate that there is no difference between the two for low-grade ores as far as results are concerned, and that, therefore, the question of preference between the two methods would have to be settled on points of manipulation.

Insufficient Grinding Caused Discrepancies

For some time unaccountable discrepancies in the results from the same sample with the phosphoric acid method, especially with high-grade ores, seemed to throw a doubt on the value of the same, but it appears that all can be traced to an insufficient comminution of the sample. The standard practice in our laboratory had been to crush to 80-mesh, and I believe with Messrs. Van Barneveld and Leaver that too much attention to this point cannot be given, the safest course being to grind all samples for these determinations to 150-mesh.

Unfortunately time did not permit these tests to be carried to a definite conclusion in regard to this and other points, and the writer would be glad to see the method subjected to a searching scrutiny so as to determine positively which of the three proposed will be the most useful for the chemist.

Among the difficulties that presented themselves in the operation of the method early in its history one was due to the peculiar conditions prevailing at the Potrerillos laboratory. This was not equipped with an electrolytic precipitation system for lack of current, and all copper determinations had to be made by volumetric methods, the cyanide for ordinary purposes and the iodide for more accurate work, the latter being too tedious for application to a large number of assays. After titration with the cyanide, however, the phosphate solution showed a decidedly yellowish tint, which greatly interfered with a sharp endpoint. After some trials with various materials Mr. L. F. Clark, our chief chemist, who [illegible] all our experimental work has been of the greatest assistance owing to his resourcefulness

and originality in solving chemical problems, found that the addition of some burnt lime (from our lime kiln), after solution of the copper had been effected and before the contents of the flask had been made ammoniacal completely removed the objectionable yellow color and left a crystal-clear liquid with which to finish the titration.

Improved Laboratory Method of Determining Copper

The operation of this method is exceedingly simple. One gram of the sample is weighed and introduced into an ordinary 500-c.c. flask with flat bottom, covered with 20 c.c. of a 15 per cent H_3PO_4 solution and an equal amount of a 20 per cent NH_4Cl solution, and boiled gently for some ten minutes. After cooling somewhat, a pinch (mustardspoonful) of burnt lime was given, the flask thoroughly shaken, and 25 c.c. strong ammonia water added. This was given another short boil, the ammoniacal copper solution filtered off from the residue, allowed to cool and titrated in the ordinary way with cyanide solution. Occasional check determinations with the iodide method gave concordant results.

The exact amounts of H_3PO_4, NH_4Cl and NH_3, as also the proper strength of the solutions could not be worked out in the allotted time, but the proportions given above answered well for all ordinary samples, up to 2 per cent and 3 per cent oxide copper. Possibly they might be reduced to advantage. On very high-grade oxide ore, say 30 per cent, to the best of my recollection a second treatment, after filtering off the dissolved copper, still yielded appreciable amounts, though I am inclined to believe that with sufficiently fine grinding this may not be the case.

Several trials with this mixture on various sulphides, both natural and artificial, to test their solubility, yielded negative results.

What Is "Oxide" Copper?

We now come to the question of what we are trying to accomplish by devising a method for the determination of oxide copper. What is oxide copper? And, is it really the oxide copper that we are endeavoring to determine? Evidently, native copper is not oxide copper, though we purposely are trying to find a way that will include it in the results, and are disappointed that the H_2SO_4 method does not do so. It is, then, to say the least, misleading to call these oxide copper determinations.

Similarly, only by some stretch of the imagination can we call the carbonates, silicates, basic sulphates and oxychlorides, "oxides." It would be better to include all of these, together with the real oxides (cuprite and melaconite) and native copper under the term of "oxidized copper." But, do we really want to know the amount of all this "oxidized copper" in technical determinations? It may be useful, occasionally, for geological or similar objects, but I know of no metallurgical process where such a knowledge could be of any utility and that, after all, should be the criterion by which to judge the value of a method. And so we come to the conclusion that each metallurgical process should have its own laboratory method, and give it its distinctive name to avoid confusion.

Effect of Iron on Drill-Samples

For instance, in the simple leaching of ores with sulphuric acid: If it were not for the presence of metallic iron in the samples from the drill-holes and bucking board, there could be no better method for the laboratory than treatment with dilute H_2SO_4, as it only represents the large scale operations *en miniature*. Unless, therefore, the samples come from other places than drill-holes and are not reduced to powder in contact with iron, a method must be found that will eliminate this iron, either by dissolving it in something that will not attack the copper oxides or some other indirect way. Removal of the iron with a magnet does not seem feasible without losing at the same time much of the sample, even if one had the assurance that all iron could thus be extracted. But, it should be possible to replace the iron completely by copper with $CuSO_4$ and then apply the dilute H_2SO_4 which will, of course, leave untouched this new copper as well as that from cuprite and the native copper, thus furnishing an accurate measure of what the leaching operations should yield. Copper-ammonium chloride might possibly be used to advantage in place of copper sulphate, provided it could be determined positively that it had no effect on the copper oxides.

Each Process Requires Special Method of Determining Copper

But, simple leaching is not the only process copper mines have to deal with. There is flotation, in acid, neutral and alkaline pulp, in sweet water and in seawater, and with all kinds of chemical agents or "drops." None of the methods touched upon in this review will help us here; each combination of processes will require one of its own, and some will prove eventually none too simple.

Take, for instance, oil flotation in acid pulp. What we need to know in this case is how much of the copper in the form of floatable sulphides is in the ore, how much in the concentrate, and how much in the tailing. In order to do this we have first to determine the total copper. Then we have to find out by some such method as described above how much of it goes into solution in the acid, leaving us, by subtraction, the amount that should be in the form of sulphide and therefore appear in the froth—provided the metallic copper acts as sulphide in that respect as some people assert and I believe to be the case, but which many people deny. If it does not, then we have to try to determine this amount of metallic copper, perhaps by amalgamation, and make allowance for it, not forgetting, in making our metallurgical balance sheet that some portion of the oxidized copper minerals must necessarily be tangled up in the gangue floated with the sulphides.

And so it will be with floating in an alkaline pulp, where the situation may, or may not be still more complicated, according to circumstances. And so it will be also with all other processes, already in use, like the combined leaching and flotation, ammonia process, etc., or those still to come, each one requiring its own laboratory methods.

Santiago de Chile

Chemistry in the Petroleum Industry*

Commercial Development—Gasoline by the Burton Process and Scientific Aspects

By William H. Burton, Ph.D.

FOUR years ago we assembled to witness the awarding of the Willard Gibbs Medal to Dr. Ira Remsen, of Johns Hopkins University, and one year ago we met for the same purpose in the case of Prof. Edward W. Morley, of Western Reserve University. Both of these gentlemen were honored preceptors of mine, and it was indeed a great pleasure to me to be present on those occasions. I never thought, however, that I would ever be the fortunate recipient of the Willard Gibbs Medal, but the unexpected and improbable very often occurs, and it is so in my case. I therefore hasten to extend to the Chicago Section of the American Chemical Society my deepest appreciation of the honor it has conferred upon me. This event reminds me of a most prominent feature in Dr. Remsen's course of instruction, namely, that the best preparation for a career in technical chemistry is thorough training in the pure science, and I was equally impressed with the introductory sentence of Dr. Morley's address last year, when he said "The best incentive for research work is the work itself." Both of these great teachers have exemplified these principles most happily in their professional careers, and I trust you will find my remarks thoroughly imbued with the influence of their invaluable instruction.

Early History of Petroleum

In considering the part that chemistry has played in the petroleum industry, it might not be unwise to review, briefly, the early history of the industry in this country. You have all heard of the first oil well, drilled by Col. E. L. Drake, near Titusville, Pa., in 1859. Prior to that time petroleum was found in small quantities floating on the surface of springs or small streams of water in western Pennsylvania, and this oil was claimed by the Indians to have marvelous curative properties in the treatment of every manner of disease. The white man, with true commercial instinct, sold the oil in bottles as a general cure-all. The demand for the oil exceeded the supply, and Colonel Drake conceived the idea that if the oil came to the surface of the springs and rivers, there must be large quantities of it in the underlying strata of the earth. He, therefore, with the most primitive machinery, drilled a well near Oil Creek, in western Pennsylvania, and before he had proceeded 100 feet into the ground the oil appeared in such large volume that it was difficult to take care of it.

At that time there was a great need for a cheap and convenient illuminating material to supplant the expensive animal and vegetable oils which were used for that purpose. Samples of petroleum (prior to Drake's work) had been sent to Professor Silliman, of Yale College, who distilled the oil and made separations according to the boiling points of the various fractions. In his report he stated that portions of these distillates might well be utilized for illuminating purposes. The promoters of the oil business acted upon Professor Silliman's suggestions, and this was the inception of the petroleum refining industry in this country.

Chemical Problems Arise

For a great many years after Professor Silliman's investigation chemistry played a very small part in the practical workings of the refining of petroleum. The refiner learned to treat the illuminating oil distillate with strong sulphuric acid and alkalis, which improved the character of it somewhat, but the methods of refining were crude and wasteful. The only portions of the petroleum which were used at first comprised the fractions boiling between 100 and 300° C., which constituted somewhat over 50 per cent. of the total mass of the crude oil. The low boiling fractions which we now comprise in the generic term of "naphthas" were thrown away, as were also the high boiling residues, called "tar." The tar, however, was soon utilized for preparing lubricating oils of very indifferent quality. It was not until about 1870, when M. L. Hull, of Cleveland, Ohio, first devised the so-called "vapor stove," that the naphtha fractions of the oil were utilized. But even then the uses for the naphtha fractions did not cause a demand equal to the supply, and much of the naphtha was wasted, a common practice being to throw it into the creeks and rivers, where it evaporated. Millions of gallons of this material, now indispensable for automobiles, were thus lost.

These conditions continued until 1885. Up to this time practically the sole source of petroleum in America was western Pennsylvania. But in 1885, or '86, petroleum was found in western and northwestern Ohio, near the town of Lima, and the fact that this oil contained from one-half of one per cent. to one per cent. of sulphur attracted immediate attention. The ordinary refining methods of distillation and treatment with sulphuric acid and alkali were found to be totally inadequate to secure refined illuminating oils of suitable quality. Therefore, the industry turned to the chemist to solve the problem of extracting the sulphur, and producing satisfactory products.

No Petroleum Chemists

It is very curious that from the early days of the industry until the discovery of Lima oil, there seemed to have been prejudice on the part of practical oil men against the chemical fraternity. Why this should have been so is not entirely clear, but I think that one reason might be the fact that manufacturers frequently called upon chemists of general training to solve some particular problem connected with their business, ignoring the fact that the chemist probably had had no practical refining experience. The chemist therefore probably offered suggestions which were totally impracticable and the manufacturer, seeing this fact, was not particularly impressed with the chemical profession as a possible aid to his business. Whatever the reasons may have been, it was a fact that in 1885, with the discovery of Lima oil, there was scarcely one trained petroleum chemist in the United States. The oil refiners, however, were forced to turn to the chemical profession for the solution of their problems, and the chemists had to become somewhat trained in the refining business before they could offer a practical solution for the elimination of sulphur from the oil. This was the starting point for a better feeling between the chemical profession and the petroleum in-

*Address by William H. Burton, Ph.D., before the Chicago Section of the American Chemical Society upon being awarded the Willard Gibbs medal.

dustry, and from that time, more and more chemists have been employed in the refining industry, until today the larger refineries depend almost entirely upon chemists to manage, not only the refinery as a whole, but the various departments of the same.

Training Chemists

In selecting a subject for an address on an occasion like this, it is customary for the candidate to choose as his subject the line of work the results of which have presumably been the reason for his being selected, and I have followed the usual procedure. It is perhaps difficult to describe the work that has been done without appearing to be somewhat boastful. However, the remainder of my remarks will be devoted largely to the results secured by the Chemical Department of the Standard Oil Company of Indiana, and I shall try to recount, briefly, the facts concerning those things which have been accomplished, and eliminate, so far as possible, the personal equation. I entered the employ of the Standard Oil Company nearly thirty years ago, at the time that the Lima oil problem was very much in evidence, and it was perfectly clear that there was a great field for chemical activity in the petroleum industry, provided the refining companies were willing to educate the chemist in the business, before expecting that the chemist would be of much value to them. The Standard Oil Company signified this willingness, and from 1890 until the present time there have been a great many chemists employed by that company, most of them being in its employ today, some as active chemists, some as general managers, and some as managers of various departments. The result has been that the refining of petroleum, instead of being a haphazard process, has been largely systematized and improved, so that when we do certain things we feel confident we will secure certain results, and the great variety of useful products made from Mid-Continent petroleum today indicate the part that chemistry has played in the petroleum industry.

The Gasoline Problem

As I indicated a few minutes ago, in the early days the supply of low boiling fractions of petroleum were largely in excess of the demand. This condition of things existed from the inception of the business until the invention of the internal combustion engine. With the advent of this machine, the demand for low boiling products, included in the commonly used name of "gasoline," became tremendous. To illustrate: In 1900 our Company was able to sell only one million barrels of naphtha products. It could have made much more, but there was no demand for it. You will recall that the automobile was devised about that time, and although the use of it grew slowly, we could see a constantly increasing demand for naphtha products to run these machines, until by the year 1910 the demand had more than trebled, and it was perfectly obvious that something would have to be done to increase the supply of these products.

In those days, the average yields of various products of petroleum were about as follows:

	Per Cent.
Naphtha products	18
Kerosene or illuminating products	30
Lubricating products	10
Loss	3

leaving about 40 per cent., which was sold for gas making or fuel purposes in lieu of coal. It was clear that the problem was to convert the high boiling fractions existing in the fuel and gas oil into low boiling fractions needed by the internal combustion engine. It has long been known that superheating the vapors of petroleum at atmospheric pressure caused dissociation of the molecules, producing very low boiling fractions and very high boiling fractions, as is evidenced by the ordinary Pintsch gas, with which you are all familiar, but the low boiling fractions produced by these superheating methods are not suitable for internal combustion engines, and the losses due to fixed gases are very great. It was found that anhydrous aluminum chloride exerted a very marked effect upon the high boiling fractions, converting some of them into low boiling fractions entirely suitable for automobile purposes, but the very high first cost of the aluminum chloride, together with the fact that to make the process successful an inexpensive method must be devised for restoring the aluminum chloride, rendered this process out of the question. We worked for almost two years trying to devise a practicable method for securing this most desirable result, first by superheating and dissociation at high temperatures, but at atmospheric pressure, and secondly, by the employment of various reagents; but our efforts were not successful; on the other hand, we met failure in every direction.

The Burton Process

It had been known for a long time that distillation of petroleum products under pressure resulted in their dissociation and production of some low boiling fractions and some high boiling fractions, but this process never had been applied in a practical way because to a practical refiner the distillation of oils under high pressures did not appeal, owing to the extreme hazard due to explosions and fires; but having tried everything else that suggested itself, we decided to attack the problem from the pressure distillation standpoint.

To the layman, distilling oils under pressure would present no particular difficulty. The distillation of water is done every day in our steam boilers, and why should one fear to do it in the case of oil? But when you consider that the distillation must take place at temperatures ranging from 350 to 450° C., where the tensile strength of steel begins to diminish very rapidly, and when you consider that steel, at such temperatures, in the presence of carbonaceous matter (and even free carbon, which often comes as the result of pressure distillation), is very likely to absorb such carbon, become crystalline and lose its tensile strength, you can readily see why the practical refiner shivered at the prospect of doing work in this way. We consulted refiners who had been in the business a great many years. We advised with mechanical engineers for whatever suggestions they might offer, and it must be confessed we did not receive very much encouragement. Since we found, early in our work, that we would require a pressure of over five atmospheres, you can easily see that we approached with considerable respect the problem of building practical apparatus that would stand this pressure in actual daily service. One refiner doubted the practicability of carrying over one pound pressure, another refiner suggested the probability of

explosions, due to polymerization of the vapors under heat and pressure, such as occur when acetylene is compressed. However, we were able to secure a very liberal sum of money to try the scheme on a large scale, and the worst that could happen would be to burn up our plant and fail in our efforts. So we went ahead.

The first large still we built had a charging capacity of 6,000 gallons of heavy oil, and about the first difficulty we encountered was serious leaks around the rivet heads and along the seams. The workmanship in building the still was good and it would have been satisfactory as a steam boiler. We found that oil, at high temperatures and pressures, leaks worse than water, and a leak always causes a fire of an intensity directly proportional to the amount of the leak. It was difficult at first to secure boilermakers who would calk these leaks while the still was under pressure. In many cases when we calked one leak another would form. Finally nature came to our aid and we were gratified to observe that as the still continued in service the leaks became less serious. The oil carbonized under the influence of the high temperature and the carbon deposits stopped the leaks.

There were many puzzling problems to be solved. We had to devise a safety valve that would operate freely in spite of the intense heat and presence of carbonaceous matter. The entire apparatus had to be constructed in such a way as to insure ease of operation and freedom from excessive repairs. Distilling oils under pressure always results in the production of so-called "fixed gases." The disposition of these gases, at first, was troublesome. We found that in some cases the heavy oil with which we started evolved more gas than was needed to maintain the desired pressure in the apparatus, whereas other oils evolved an insufficient amount of gas for this purpose. This was an embarrassing situation, but we converted an obstacle into an aid by arranging a large number of stills in parallel so that the superfluous gases from some stills were conducted to others that needed them and this plan gave us a perfect method for securing uniform pressure and control—a most essential feature in the work.

The first large still we built, as I have mentioned, had a capacity of 6,000 gallons, and by starting with fuel oil products having boiling points ranging from 200 to 350° C., we were able to secure a very substantial yield of a product having boiling points ranging from 50° C. up to 200° C., and to our great gratification the losses incurred thereby were trifling, averaging less than three per cent. We were astonished, also, to find that the high boiling residues thus produced yielded a product almost identical with the natural asphalt which is mined in large quantities in the island of Trinidad. Evidently we are doing artificially what Nature has done in ages gone by, viz.: distilling petroleum under pressure.

It would require a long time to describe how we solved some of the various problems that arose in connection with this process. From the single 6,000-gallon still we first built, we now have over five hundred stills of a larger capacity. At first our practical men were very loath to accept these pressure stills as a going proposition. They were afraid of them. The minute the slightest thing happened they would be likely to run. But, fortunately, we had no fires or serious accidents for the first two or three years, and when we finally did have a rather bad fire, the men had secured enough self-confidence to stand by their guns, and the damages were repaired quickly and the work went on, so that today the work pressure distillation is carried on in our refineries in connection with the regular routine work, and most of us have forgotten that a few years ago we were met with discouraging protests when we proposed making naphtha products in this manner. During the last five years there have been made in this country over 20,000,000 barrels of gasoline or naphtha products by the use of these stills, and we trust that the future will show a largely increased production (by this process) of this indispensable material.

Future Work for Chemists

Although we know very little about the reactions that occur when petroleum is distilled under pressure, it may be interesting to speculate a little on this subject. Let us start with the paraffin $C_{14}H_{30}$ and see what might happen.

$$C_{14}H_{30} = C_{13}H_{28} + CH_4$$
$$C_{14}H_{30} = C_{12}H_{26} + C_2H_4$$
$$C_{14}H_{30} = C_{14}H_{28} + H_2$$
$$C_{14}H_{28} = C_{12}H_{26} + C_2H_2$$

$$C_{14}H_{30} = 4C_2H_2 + 4CH_4 + C_2H_2 \text{ (All gas)}$$

$$2C_{14}H_{30} = C_8H_{18} + C_{20}H_{42}$$
$$C_{20}H_{42} = C_4H_{10} + C_{16}H_{32}$$
$$C_{12}H_{24} = C_{10}H_{22} + C_2H_2$$

$$2CH_4 + C_2H_2 = C_3H_{10}$$
$$3CH_4 + 2C_2H_2 = C_7H_{16}$$
$$C_2H_2 + 2H_2 = C_2H_6$$

We feel confident that the finished gasoline contains such paraffins as C_8H_{18}, $C_{10}H_{22}$ and $C_{12}H_{26}$, but one of the most interesting results is the formation of free hydrogen as shown in one of the above equations.

The fixed gas formed in pressure still work gives the following analysis:

	Per Cent.
CH_4	56.3
C_2H_6	25.8
Unsaturated hydrocarbons	8.5
CO	.8
H	7.4
Condensible vapor	.6
Undetermined	.6
	100.00

It would seem almost impossible for hydrogen to be set free under the conditions mentioned above, but the analysis of the gas proves this to be a fact. It also seems probable that, under the influence of heat and pressure, the gases of the different series polymerize to form saturated products that are useful.

It is perhaps to be regretted that the chemists engaged in the petroleum industry have contributed so little to the purely scientific side of the subject. Others have done considerable work along this line, but for various reasons, the petroleum chemists have not. The chemistry of petroleum offers a most inviting field for

scientific research, and I trust the time will come when this subject will receive the attention it deserves, and when that time does come, I sincerely hope the chemists who have been trained in the practical work will be in a position to do their bit for the advancement of our knowledge of the chemistry of petroleum.

Shares Tribute with Associates

It would be most unjust and unfair for me to accept at your hands the award of the Willard Gibbs Medal without acknowledging to you the invaluable assistance that I have received from my associates, several of whom I see before me in this room. They are fully entitled to their share in the honor that goes with this medal. Some of these gentlemen are chemists and some, although not having a thorough chemical training, are worthy to be called chemists.

It has fallen to my lot to be the director of the work I have just outlined, but it never could have been brought to a successful termination without the valuable suggestions, indefatigable labor and loyal support of my associates.

Standard Oil Company,
Chicago, Ill.

Activities and Personnel of the Chemical and Explosives Section of the War Industries Board

Leland L. Summers, Chief of Explosives Section
Chas. H. MacDowell, Chief of Chemical Section

Mica	Handled by J. H. Adams
Acids and Heavy Chemicals	" " Albert Brunker, A. E. Wells and R. S. Hubbard
Alkalies and Chlorine	" " H. G. Carrell
Wood Distillation Products (Acetates and Wood Alcohol), Platinum and Platinum Metals, Commandeering, Requisitioning	" " C. H. Conner
Toluol Distributions, Creosote	" " Ira C. Darling
Tanning Materials, Tallows, Greases, Vegetable Oils and Waxes	" " E. J. Haley
Pigments and Paints	" " R. S. Hubbard
Coal, Gas Products—Benzol, Toluol, etc., Rare Gases, i. e., Argon, Helium, Nitrogen, Oxygen, etc.	" " J. M. Morehead
Nitrates	" " Chas. H. MacDowell
Fine Chemicals (including Medicinal chemicals. Analytical, Photographic)	" " A. G. Rosengarten
Manganese, Chrome, Tungsten, Ferro-Alloys	" " H. W. Sanford
Explosives	" " Leland L. Summers
Glass—Chemical Carboys, Chemical Stoneware	" " Robt. M. Torrence
Brimstone (Sulphur), Pyrites, Alcohol, Ethyl or Grain	" " Wm. G. Woolfolk
Inorganic Chemicals, Metallic and Non-Metals, Electrolysis, Electro-Metallurgy, Electric Furnace, Ceramics and Refractories, Organic Compounds and Dyestuffs	" " Dr. H. R. Moody, Dr. Samuel A. Tucker, Dr. E. R. Weidlein, (Consulting staff)

The Effect of Boiling Sulphur on Copper

By Carle R. Hayward

THE great affinity of sulphur for copper has long been a well-known fact. One of the experiments customarily used in elementary chemistry to show how two elements may be united to form a compound makes use of this affinity. Copper filings and sulphur are mixed together and heated in a test tube, causing the copper to be transformed into a sulphide. When several pounds of sulphide are desired for experimental purposes it is quite natural to mix copper and sulphur in a crucible and heat until fusion takes place, but the sulphide produced by this method usually does not some pure Cu_2S for evperimental purposes and found necessary to break up the mass, add more sulphur and fuse again.

Several years ago the writer had occasion to prepare some pure Cu_2S for experimental purposes and found a modification of the above method more satisfactory.[1]

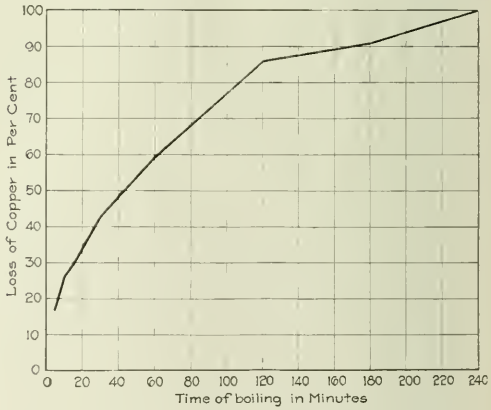


FIG. 1. AVERAGE PERCENTAGE LOSS OF COPPER

Some copper turnings were placed in a large casserole and boiled in sulphur for an hour. On pouring off the sulphur a porous mass remained composed of particles the shape of the original turnings but larger in size. No sign of metallic copper remained. In order to assure complete conversion to Cu_2S, the mass was removed from the casserole, mixed with 15 per cent sulphur and melted in a graphite crucible. After remaining molten for five hours the melt had the composition desired.

An attempt to produce nickel and iron sulphides by this method was unsuccessful. The shavings were practically unattacked by the sulphur.

The boiling of the shavings in the above case was continued for an hour but no attempt was made at the time to ascertain whether an hour was necessary or not. Recently tests have been made to determine the rate of penetration of boiling sulphur into copper and although the results may have no commercial value they bring out several interesting points.

[1] The Equilibrium Diagram of the System Cu_2S-Ni_3S_2. Trans. A. I. M. E., XLVIII, 141-52.

Rate of Penetration of Sulphur into Copper

The copper used in the experiments was in the form of hard-drawn rods ¾-inch in diameter. The rod was sawed into ¾-inch lengths, thus giving a cylinder the length of which was nearly twice as great as the diameter. The specimens were placed separately in iron crucibles containing boiling sulphur which was kept boiling for periods of time varying from five minutes to five hours. At the end of the treatment, the specimen was removed and the adhering sulphur allowed to burn off. The specimen was then weighed, after which it was broken open and the copper core remaining was weighed. The core dropped out when the specimen was broken and the surface was clean. In the specimens where no copper remained, there was a hollow space at the center of the shell. The boiled specimens were in all cases larger than the original and the edges were rounded off. The increase in diameter varied from $\frac{3}{32}$ inch in the five-minute specimen to ¼ inch in the four-hour specimen. The results are given in Table I.

TABLE I. ALL WEIGHTS IN GRAMS

Time Boiled	Weight Before	Weight After	Gain in Wt	Weight of Core	Loss of Copper	Per Cent. Loss Cu	Loss of Cu Gain in Wt
5 min.	14 62	15 41	0 79	12 37	2 25	15 4	2 85
5 min.	10 00	10 52	0 52	8 16	1 84	18 4	3 54
5 min.	9 99	10 48	0 49	8 22	1 77	17 7	3 61
10 min.	12 39	13 54	1 15	9 39	3 00	21 2	2 61
10 min.	10 00	10 72	0 72	7 65	3 07	30 7	4 26
10 min.	9 99	10 70	0 71	7 42	2 52	25 2	3 55
15 min.	14 64	15 85	1 21	10 45	4 19	28 6	3 46
15 min.	10 00	10 96	0 96	6 86	3 14	31 4	3 27
15 min.	9 99	10 81	0 82	7 15	2 84	28 4	3 54
30 min.	13 68	15 08	1 40	8 92	4 76	34 5	3 40
30 min.	10 00	11 35	1 35	5 60	4 40	44 0	3 26
30 min.	9 99	11 44	1 45	5 35	4 64	46 4	3 20
30 min.	10 00	11 29	1 29	5 48	4 52	45 2	3 50
1 hr.	9 99	11 86	1 87	3 75	6 24	62 4	3 34
1 hr.	10 00	12 11	2 11	3 00	7 00	70 0	3 31
1 hr.	9 70	11 27	1 57	4 34	5 36	55 3	3 41
1 hr.	9 99	11 63	1 64	4 41	5 58	55 8	3 41
1 hr	10 00	11 50	1 50	4 82	5 13	51 3	3 43
2 hr	10 00	12 66	2 66	1 02	8 93	89 3	3 36
2 hr	10 00	12 36	2 36	1 43	8 52	85 7	3 63
2 hr	10 00	12 46	2 46	1 72	8 28	82 8	3 36
3 hr	12 22	15 53	3 31	0 56	11 66	95 5	3 52
3 hr	9 99	12 27	2 78	0 80	9 19	91 9	3 31
3 hr	10 00	12 65	2 65	1 16	8 84	88 4	3 33
4 hr.	9 73	12 51	2 88		9 73	100 0	3 38
5 hr	9 82	12 85	3 03		9 82	100 0	3 24

The average results are given in Table II and the average percentage losses of Cu are plotted in Fig. 1.

TABLE II

Time Boiled	Gain in Weight of Sample	Loss in Weight of Cu	Per Cent. Loss of Copper	Ratio Av. Loss of Cu / Av. Gain in Wt
5 min.	0 60	1 95	12 2	3 25
10 min.	0 86	2 86	25 9	3 33
15 min.	1 00	3 39	29 5	3 39
30 min.	1 37	4 58	42 6	3 34
1 hr.	1 74	6 00	59 0	3 44
2 hr.	2 49	8 59	85 9	3 45
3 hr.	2 91	9 90	91 9	3 40
4 hr.	2 88	9 73	100 0	3 38
Average ratio				3 37

The gain in weight can be due only to the taking on of sulphur from the bath and it is fair to assume that this sulphur unites with the copper to form sulphide. It will be noticed, however, that the ratio of Cu to the gain in weight is in every case less than the ratio of Cu to S in Cu_2S which is 3.97. This indicates that the shell produced contains either elemental sulphur mechanically held or a higher compound of Cu and S.

Composition of the Sulphide Shell

In order to determine if possible the exact composition of the sulphide shell, one specimen from each period of boiling was pulverized, washed in CS_2 and analyzed for Cu. The results are shown in Table III.

It is seen from Table III that there is a slight tendency toward a lower copper content as the time of boiling is increased, but with the exception of the

TABLE III

Time Boiled	Cu	S	Per Cent. Cu
5 min.	78 12	2 1	77 24
10 min.	77 98	2 1	77 14
15 min.	78	4 1	77 37
30 min.	77		
1 hr.	77 72		77 58

five-minute specimen there is only a difference of 0.38 per cent of copper between the highest and lowest figures so it is possible that the product has in reality the same composition in each case.

The average analysis of the specimens is 77.58 Cu, giving a ratio of Cu to S of 3.42, which is slightly larger than the ratio between the average loss in weight of the copper core and the average gain in weight of the boiled specimen (See Table II).

Several of the specimens were examined under the microscope and revealed traces of CuS near the edge of the section. It seems probable, therefore, that the CuS acts as a carrier of sulphur from the bath to the metal.

The formula which most nearly corresponds to the composition of the material obtained is $5Cu_2S.2CuS$, which contains 77.31 per cent copper.

The results may prove of interest to the geologist in studying the formation of covelite and chalcocite or may have a bearing on the phenomena in kernel roasting.

Massachusetts Institute of Technology
Cambridge, Mass.

Mining Engineers Drop Enemy Aliens

At a meeting of the Board of Directors of the American Institute of Mining Engineers held Wednesday evening, May 29, important resolutions were passed affecting enemy alien members of the Institute. The first resolutions proposed were modified to more nearly meet the approval of the directors present and the following were finally adopted after considerable discussion during which strong views were presented both for and against the proposal. In their final form these resolutions will scarcely find objectors among Institute members:

"Resolved, That all honorary members, members, associate, and junior members who are enemy aliens, residing in enemy countries, be dropped from membership in the American Institute of Mining Engineers, and their names be, and they are, stricken from the rolls.

"Resolved, That the Membership Committee be requested to advise this Board of Directors of the names of all the above mentioned persons, and in addition the names of all other enemy aliens, members of the Institute, and be it further

"Resolved, That, in the case of said latter class, this Board shall consider and act upon the question of expulsion after ascertaining their attitude toward the Government of the United States."

The action of the Board of Directors will affect immediately 21 Germans and 1 Austrian who hold either honorary or active membership in the Association. A thorough census will be taken of all other enemy alien members with a view to ascertaining their loyalty to the United States.

Synopsis of Recent Metallurgical and Chemical Literature

Viscosity of Blast-Furnace Slags.—Very important work from a theoretical and practical standpoint on the viscosity of iron blast furnace slags has been completed at the Pittsburgh station of the Bureau of Mines by A. L. FEILD and associates. A description of the problem and methods of solution was published by Mr. Feild in the *Transactions* of the Faraday Society, 1917, Vol. 13, part I, while recent *Bulletins* of the American Institute of Mining Engineers contain abstracts of Bureau of Mines *Technical Paper* No. 189, containing a record of the scientific data obtained, and of Bureau of Mines *Technical Paper* No. 187 on "Slag Viscosity Tables for Blast Furnace Work."

Silicates in general pass from a solid to a mobile liquid by a series of imperceptible steps. Lacking the characteristic of the sharp melting points of a pure compound, many determinations of the "softening" temperature have been made, wherein the deformation of a cone-shaped sample was observed. This "softening" temperature, according to Mellor, is that temperature where the inward surface pressure overcomes those intermolecular forces preventing an orientation conforming to the minimum surface of stable equilibrium. The softening of cones is therefore the resultant of the viscosity decrease, the action of surface forces, and the action of gravity. In general, the softening of silicates depends upon the amount of eutectic present; if a large amount of fusible eutectic is contained in the solid, softening may easily occur at a low temperature even when the viscosity of the fused portion is high.

The studies in viscosity described in these papers were made in a modified Margules apparatus (See METALLURGICAL AND CHEMICAL ENGINEERING, Vol. 15, page 541). The powdered slags were placed in a crucible made of 1½-inch round graphite electrode, bored ¾ inch (diameter = b) 3 inches deep, and heated in an improved "gran-annular" furnace. This furnace was surrounded with a tight iron casing, and an atmosphere of CO+N maintained. Into the slag was immersed a ½-inch (diameter = a) graphite cylinder, hung from a balanced astatic spring-suspension. On being rotated slowly at an angular velocity w the viscosity of the slag caused a measured couple c in the inner cylinder suspension which is related to the viscosity n as follows:

$$C = 4\pi nL \frac{a^2 b^2}{b^2 - a^2} w$$

where L is the common length of the two cylinders, disregarding end effect. Viscosity determinations were thus made at intervals during a regular heating and cooling cycle, the upper limit being the temperature resisted by the lundum furnace cores, and the lower the strength of the inner-cylinder suspension. Thirty-six viscosity tables are given in *Technical Paper* 187 covering all commercial iron blast furnace slags figured on the basis of $CaO+SiO_2+Al_2O_3 = 100\%$, covering each even per cent of alumina from 7 to 24, and their use explained by reference to specific problems in blast furnace practice.

The determined data indicate that the compounds which are stable in solid slags, (for instance: gehlenite and calcium metasilicate), do not decompose thermally into their constituent oxides on melting, for the following reason: The temperature-viscosity curve of the slag represented by Rankin and Wright's quintuple point 2 (see *American Journal of Science*, Vol. 39, page 1), was determined over a viscosity range from 100 to 2000 and yielded an equation between temperature T and fluidity f (fluidity is the reciprocal of viscosity) as follows, correct to plus or minus 5.5 deg. C.

$$T = 1167 + 7.37\ f - 4.45\ f^2$$

if this equation may be extrapolated from $f = .0005$ to $f = 0$, it shows that 1167 deg. C. is the temperature where viscosity becomes infinite, which, by the way, is Maxwell's criterion of the solid state. Rankin and Wright determine the melting point at 1170 deg. C. plus or minus 5, by noting the change in optical properties from the crystalline to the amorphous state. If therefore, the melting point of a mixture of compounds can be thus predicted from the behavior in the fluid state, the compounds certainly do not dissociate immediately or discontinuously on melting.

Such considerations affect the conceptions of slag action such as desulphurization. At slag forming temperature the sulphur (mostly introduced as coke ash) is almost entirely in the iron. The reaction generally given to cover its transfer to the slag is

$$FeS + CaO = CaS + FeO$$

with the following side reaction

$$FeO + C = CO + Fe$$

the two ordinarily combined as

$$FeS + CaO + C = CO + Fe + CaS$$

This latter reaction is now seen to depend upon the hypothetical thermal dissociation

$$Ca_2Al_2SiO_7 = CaSiO_3 + CaAl_2O_4$$
$$CaSiO_3 = CaO + SiO_2$$
$$CaAl_2O_4 = CaO + Al_2O_3$$

The final distribution of sulphur therefore depends upon the equilibrium constants of the last four equations. Disulphurization cannot simply be expressed in terms of the per cent of CaO in the slag, nor even worked out from Nernst's distribution law and the law of mass action if applied to the uppermost reaction only.

The reactions of desulphurization take place at the iron: slag interface, and the CaS formed there must diffuse into the slag at a speed high enough so that the reaction may continue until it reaches an approximation of the equilibrium ratio between sulphur in the iron and slag in the limited time available. A high hearth temperature which will promote fluidity and thermal dissociation of a properly constituted slag will promote desulphurization, provided the slag viscosity is not so low as to release its trapped iron globules too quickly. The reduction of silicon never approaches equilibrium, and the amount of silicon in the metal is therefore independent of the slag viscosity, *per se*. Consequently, high temperature, long contact, or both, favors a high silicon, low sulphur foundry iron. A moderate temperature and moderate time in contact produces low silicon and moderate sulphur, as does also a high temperature and short time of contact. These conditions are present in the furnace when making basic

iron, either with a very basic slag and a light burden, or with a somewhat basic slag and a heavy burden.

Since the composition of a blast furnace slag determines the rate of change of the temperature-viscosity curve, it determines the temperature of the smelting zone at a given rate of driving, and the length of time the iron is in intimate contact with the slag. The intelligent use of such relations would therefore reduce the losses in off-grade pig, improve fuel economy, promote operating efficiency, and extend present practice to cover lean and complex ores. Furthermore, since the radius of iron globules in contact with the slag approximates a constant quantity under operating conditions, the loss of metallic iron in slag should be directly proportional to the viscosity of the slag at the hearth temperature and to the rate of pig production.

Physical Constants of Ammonia.—NATHAN S. OSBORNE and M. S. VAN DUSEN have given the results of recent researches on the physical constants of ammonia in Bureau of Standards *Scientific Papers* Nos. 313, 314, and 315. The specific heat of saturated liquid ammonia was determined by two independent methods, using calorimeters specially adapted for the work, and an empirical equation devised which expresses the experimental results to within one part per thousand. The specific heat σ in joules per gram per degree centigrade, of liquid ammonia, kept saturated, at the temperature θ, is given in the range —45° to + 45° C, by the equation

$$\sigma = 3.1365 - 0.00057\theta + \frac{16.842}{133 - \theta}$$

The latent heat of vaporization was also determined and the following equation derived with the same degree of accuracy: The latent heat of vaporization of ammonia, that is, the heat required to convert saturated liquid into saturated vapor at constant temperature, in joules per gram, is expressed for the range -42 to -52 deg. C. by the equation:

$$L = 137.91 + 133 - \theta - 2.166\ (133 - \theta)$$

If the latent heat of vaporization is expressed in calories$_{20}$ per gram, taking 1 calorie$_{20}$ = 4.183 joules, the equation becomes

$$L = 32.968 + 133 - \theta - 0.5895\ (133 - \theta)$$

The transformation of energy into heat or vice versa, resulting from a change in pressure in liquid ammonia has also been determined by three independent methods, and tabulations for the range — 40 to + 40 deg. C. are presented.

Fine Grinding at Inspiration, Miami, and Anaconda.—Criticizing Mr. C. T. Van Winkle's paper on "Recent Tests of Ball Mill Crushing", E. H. KENNARD, who conducted the Inspiration tests for Mr. Hardinge, called attention to the close and expert attention necessary for a ball mill and ascribes the excellent performance of the Marcy mill to the experience in its handling gained by the operators in two years' practice, and the poorer production of the Hardinge type to improper location and defective arrangements for handling the pulp. The table of relative performance is also claimed to be misleading in that it is merely the record of a single day's run.

A. E. WIGGIN, superintendent of concentration for the Anaconda Copper Mining Company, said that previous to remodeling the Washoe concentrator a Hardinge pebble mill of 10-ft. diameter and 4-ft. cylinder was tested in comparison with an 8- x 12-ft. Power and Mining Machinery Co. tube mill, using pebbles and having a trunnion discharge. The results showed the Hardinge mill to be slightly superior, but he always considered the trunnion-discharge tube-mill and the Hardinge mill to be on a par as regards efficiency and costs of fine crushing. As they were obliged to order mills to remodel the entire concentrator without waiting the results of any more testing, and as they had experienced much mechanical difficulty and delay in deliveries with the tube-mill, it was decided to order Hardinge mills, and they saw no good reason for ordering any other size than the one they had tested. Since they had few data as to the relative merits of iron-ball vs. pebble crushing, they figured tentatively that while for pebble-crushing eight 10- x 4-ft. mills using 150 horsepower each would be required per section, for ball-crushing the same amount of material it would require four or five mills lagged down to 8 ft. in diameter, and using considerable more power. A compromise of 6 mills and 225-horsepower motors was finally agreed upon. Changing the shape of the mill did not, in any way that they have been able to detect, increase the efficiency of the Hardinge mill. The one factor which was responsible for the great improvement in their crushing efficiency is the reduction in the speed of the mills. When these were converted into iron-ball mills, 7½ x 6 ft. in size, the speed was first maintained at the original 23 r.p.m. Tests were later made at lower speeds, and at the conclusion 15 r.p.m. was fixed as the most efficient speed for these mills. This diminished the power consumption from 215 to 140 horsepower per mill, or a total of 2250 horsepower, and the ball consumption from 4.5 to 3.25 lb. per ton crushed, totalling 13,500 lb. per day, and, of course a considerable saving in lining and general repairs. The tonnage crushed and the fineness of the crushing are unaffected, and the savings from the two items mentioned amounted to over $250,000 per year.

Tests of American and Foreign Chemical Glassware

Prior to the summer of 1914 the greater part of the chemical laboratory glassware used in this country was imported from Germany and Austria. The cutting off of imports from these countries caused a very serious shortage of glassware in this country, which is not yet entirely overcome. However, within the past two years a number of American manufacturers have increased their production of such ware.

In order to furnish to chemists information regarding such domestic brands, it was decided by the United States Bureau of Standards to compare them with those of foreign make. These results of the bureau's tests indicate that all of the American-made wares tested are superior to Kavalier and equal or superior to Jena ware for general chemical laboratory use. Results of these tests are given in Technologic Paper, No. 107, "Comparative Tests of Chemical Glassware," which may be obtained from the Superintendent of Documents, Government Printing Office, for 10 cents.

Recent Metallurgical and Chemical Patents

Continuous Zinc Smelter. — A continuous zinc smelter has been patented by WOOLSEY MCA. JOHNSON, of Hartford, Conn., illustrated in Fig. 1, and consisting essentially of a continuous complex retort heated at the receiving end by ordinary fuel, and by electricity at the fusion end, provision being made for the recovery of various products according to the temperature of their evolution. Pre-roasted ore, containing more than the usual amount of sulphur left in zinc ore designed for retort smelting, is mixed with a suitable amount of coal, preferably of a sort involving enough volatiles to create a draft in the pre-heating operations and the mixture is introduced into the proper hearth 5. The ore is rabbled from each hearth to the next lower, and continuously subjected to a temperature of about 1050 deg. C., which is maintained by the conduction of heat through the retort walls from hot furnace gases circulating from the fireplace A through the passageways enveloping the pre-heating hearths. During this passage considerable sponge iron is formed, practically all the cadmium is evolved, and the ore is finally fed into the electric smelting furnace continuously through the downtake 30. Here the charge is smelted at a high temperature, the liquid portion being tapped at intervals and separated into metallic iron, molten matte, and a slag, while the zinc is volatilized, led into the condenser 43 and eventually drawn off and cast into bars from spout 45. (1,244,504, Oct. 30, 1917.)

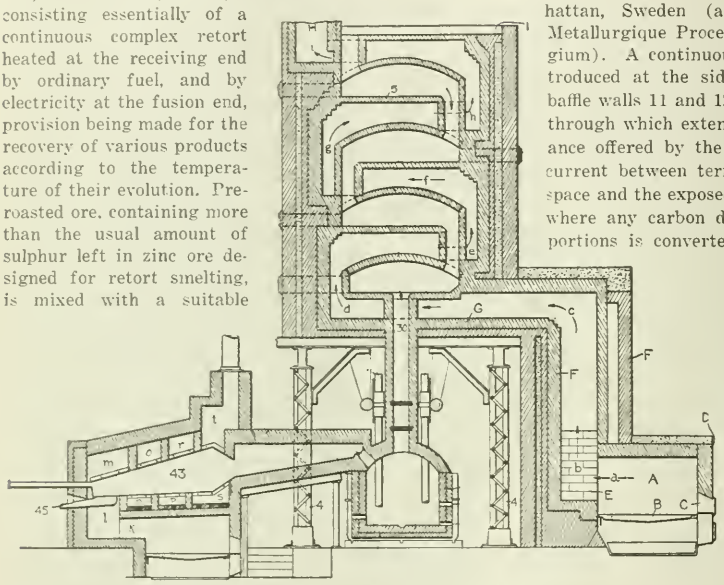


FIG. 1. JOHNSON CONTINUOUS ZINC SMELTER

Electric Furnaces for Zinc Reduction.—The method of extracting zinc from ores illustrated by means of Fig. 2 is patented by E. A. JOHANSSON, of Trollhattan, Sweden (assigned to Société Anonyme Metallurgique Procedes de Laval, of Brussels, Belgium). A continuous supply of cold charge is introduced at the sides of the furnace behind the baffle walls 11 and 12, which enclose a vacant space through which extends the electrode 2. The resistance offered by the charge to the passage of the current between terminals heats the entire vacant space and the exposed surface of the heap to a point where any carbon dioxide generated in the cooler portions is converted to monoxide on passing out through the heated surface. (1,256,802, Feb. 19, 1913.) FILIP THARALDSEN, of Christiania, Norway, observes that in smelting any heap of ore as mentioned in the preceding, the reduction and melting does not take place evenly over the surface of the heap as intended, but the localized action of the arc will eat cavities into the charge, the walls of which will eventually collapse, with the formation of quantities of undesirable dust. He therefore proposes the furnace sketched in Fig. 3, where a heap of ore charged into auxiliary chamber *b* at the left is struck out into a flat sheet by the movement of the car-body-hearth, and this flat sheet of ore smelted by radiation from a bare arc in the central chamber *a*. As the movement of the car proceeds to the right, the smelted residue is removed by the rake *k* as it enters chamber *b*. As the first charge is exhausted, a new portion of ore is dropped into the right hand chamber *b*, the movement of the hearth reversed, and the process continued as before. (1,255,066, Jan. 29, 1918.)

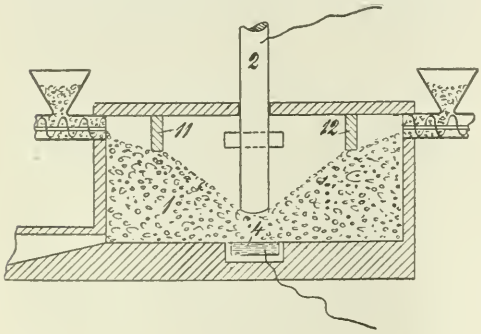


FIG. 2. JOHANSSON ELECTRIC ZINC FURNACE

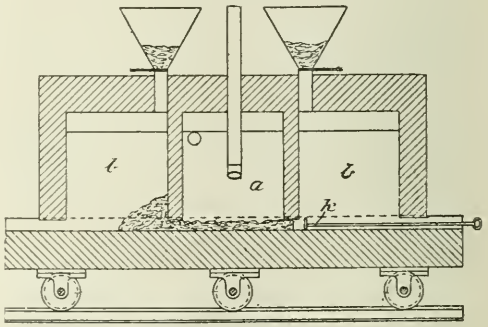


FIG. 3. THARALDSEN ELECTRIC ZINC FURNACE

Tiering in Freight Cars

TO UTILIZE all the storage space in freight cars is now a Government necessity and the piling of material that is required. At the same time, labor is so scarce

MACHINE FOR TIERING GOODS IN FREIGHT CARS

that concerns shipping heavy goods, such as rolls of paper, cases, bales, crated machinery, etc., are having difficulty in getting this work done. For this purpose the Revolvator Co., of Jersey City, N. J., has developed a portable tiering machine. By means of this machine one or two men can pile the goods clear to the roof of the car. The illustration shows one man tiering a 1000 lb. bale of waste inside a freight car. Without the machine, at least four men would be required.

New Design of Sextuple Effect Evaporator

THOSE who have to deal with the distilling of sea or other water or with evaporation problems in general kind, will be interested in a design of Lillie evaporator now being built by the Wheeler Condenser & Engineering Co., of Carteret, N. J. It is a modification of a regular Lillie sextuple effect sea-water distilling apparatus. Two of these now under construction are to be operated by steam up to 60 lb. per sq.in. gauge pressure, or at any lower pressure.

Four condensers, side by side, are employed as shown in the illustration.

This arrangement of condensers permits seven different combinations of operation, as follows:

1. It may be operated as one single effect or more single effects;

2. It may be operated as one or more double effects, with vapors reversible in each;

3. It is possible to operate it as a triple effect, or as two triple effects, with vapors reversible in each;

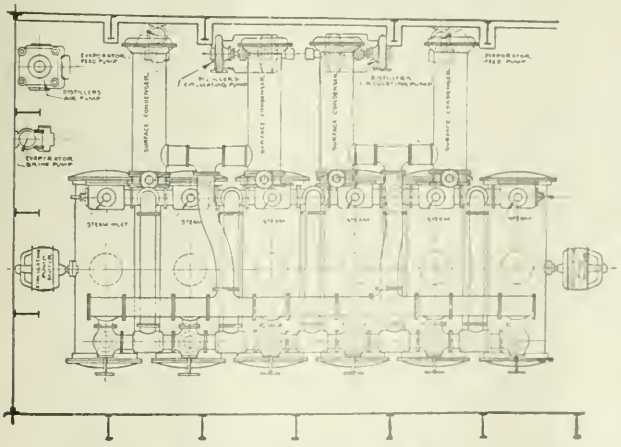
4. It is impossible to operate it as two quardruple effects, but every effect may be utilized by grouping as one quadruple effect and one double effect, in both of which the vapors are reversible;

5. It may be operated as one vapor reversible quadruple effect with both end effects or either end pair of the section cut out;

6. With one effect at either end cut out, it may be operated as a vapor reversible quintuple effect.

7. Lastly, it may be operated as a vapor reversible sextuple effect.

It is evident that should a mishap occur at either end, in the middle, or anywhere else, there is little danger that this evaporator will be put out of commission entirely.



SEXTUPLE EFFECT EVAPORATOR

Enemy Piracy of Trade Marks

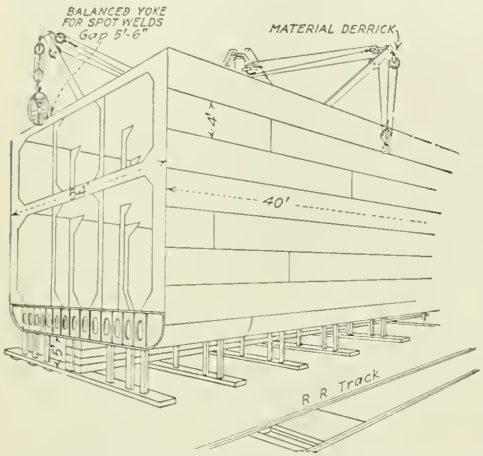
Our attention has been directed by Dr. L. H. Bakeland of the Naval Consulting Board to a new form of enemy piracy relating to trade marks of American manufacturers. Certain countries recognize the first to register a trade mark as the rightful owner and hold that the subject is not open to further discussion. Argentina, Brazil and Chile are among those in which the rule prevails.

There is also a Trade Mark Convention among the following countries with headquarters at Berne: Austria, Belgium, Brazil, Cuba, Spain, France, Hungary, Italy, Mexico, Holland, Portugal, Switzerland and Tunis. On payment of a fee of 100 francs to the central bureau by any member of the Convention, the ownership of a trade-mark is registered in all 13 countries. Austrian firms have been active in this respect and as an example, Mr. Richard Mittler of 6 Wiesingerstrasse, Vienna, has registered as his, Ajax, Federal, Firestone, Fisk and Republic automobile tires, unless the actual owners were there before him. Additional instances are known of the registration by a German, formerly resident in Belgium, of the names of three well-known American typewriters, of Jap Rose Soap, Foos Gas Engines and the Waukegan mark of the American Steel and Wire Co.

The State Department has the matter in hand. American manufacturers are urged to register their trademarks in other than enemy countries without delay.

Test of Electric Welding for Steel Ships

THE purposes and possible benefits of the ship welding test now being conducted at the Federal Shipbuilding Company plant at Newark, N. J., are outlined in a report by Arthur J. Mason, vice-president of the corporation. We quote in part from the report as follows: Electric welding in its various phases has for years been employed in shipyards and in the arts generally, but for a number of reasons the work has been confined to odd jobs and repairs. The proposal to extend its use to the major part of ship construction has met with gratifying approval from the shipbuilder. It remains for us through this large test to demonstrate its economy in time and money and its adequacy to build a stanch ship.



PART OF SHIP'S HULL THE PLATES OF WHICH ARE BEING JOINED PARTLY BY RIVETING AND PARTLY BY WELDING

The purpose of this test is to demonstrate these advantages—to do it in such a way that all may see and contribute, and finally to test the structure itself so completely that there will follow a heart-whole and unanimous belief in the method.

The test itself will take the form of building part of a hull at the Federal Shipbuilding Company's plant, Newark, N. J.

A 10,000-ton ship, costing $2,000,000, now costs but $70,000 to rivet. It must be plain that if electric welding only promises to modify this amount no very substantial gain offers.

Splendid benefits we all feel do offer themselves in the possible change in the whole regime of shipbuilding. Our test has in view abolishing, or greatly diminishing:

1. The railroad journey from rolling mill to fabricating plant, when the latter is not at the shipyard.
2. The templet makers' work.
3. The makers' work.
4. The punching.
5. Much of the work of fitters and bolters who flog and pull the pieces to fit on the ways. There lies in the above items an excellent likelihood to save a month's time in construction and a saving of no less than $40 a ton in the cost of steel structure, at least $100,000 a hull on a 10,000-ton vessel.

Briefly the program is to assemble a hull rapidly by spot welding, tacking the ship together much as a tailor bastes his work in assembling a suit of clothes. The structure then becomes a house favorable for work in all weather and at night in which the completion of the ship may go on.

After the material is thus assembled and fastened with spot welds, so that it is sufficiently strong to hold its shape, the work is completed by arc welding all seams to insure strength and render the work watertight. Roughly we expect the spot welds to be about 10 in. (25.4 cm.) apart.

One-quarter of the structure will be riveted, the other three-fourths welded, so that the tests of strength will afford a basis of comparison.

Electric welding offers a great field for lightening a ship. In this design various views of this opportunity will be tried out. The field here is very great —ultimately 10 per cent of the steel may be eliminated.

One derrick will bring material, the other derrick support the spot-welding yoke, whose function is to tack the material together, fastening the plates either to the frames or to the adjoining plates.

The problems of fitting in place the parts of a hull are almost wholly problems arising out of the necessity to make a number of little holes in a plate made by one man at one time and place fit a number of little holes made by another man at another time and another place.

Once all holes are left out of the material, all parts fit. The creeping and kindred problems so perplexing to the shipbuilder disappear. Every plate becomes a closer. Every plate justifies itself.

The manufacture of the spot-welding yoke and appliances is placed in the hands of the Universal Electric Welding Company of Long Island City. The design of the yoke is completed, the patterns are made and steel castings will be forthcoming in the next ten days. The early stages of the arc welding are to be accomplished by the Wilson Electric Company, which was so successful in the work on the German ships' repairs, but it is the intention to call in all men with ideas and apparatus and to give them a field to test out in actual work. To this end Professor Adams' committee is searching out all available talent.

An adequate system of testing the work when done is under consideration. The primary test will consist of filling the hull with water and shifting the points of support under continual and close scrutiny, as one-quarter of the whole will be riveted in the normal manner. There will be always a gage of comparison with that portion which is welded.

Likewise there will be a chance for comparison of the two forms when subjected to abuse by bumping with rams and in various other ways.

Lord Reading, British Ambassador, while inspecting the Hog Island shipyard with Charles M. Schwab, where an 8500-ton freighter is to be finished every 48 hours, said: "Give us ships like this and we will win the war even should the Germans reach the Channel Ports or Paris."

Book Reviews

METHODS FOR TECHNICAL SAMPLING AND ANALYSIS OF GASES. Copyright 1918 by *J. M. Camp*, Chairman Chemists' Committee, United States Steel Corporation, Pittsburgh.

This revised second edition of the pamphlet on gas analysis has been prepared by a committee of chemists from several of the plants of the U. S. Steel Corporation. Like the first edition it is an example of the technical benefits resulting from bringing into one large organization a number of separate units with their combined experience and knowledge. It is doubtful whether a better set of technical methods of gas analysis could be compiled.

This is very similar to the first edition (reprinted in METALLURGICAL AND CHEMICAL ENGINEERING, Vol. IX, pp. 302 and 356). Additions have been made to the text in the way of a method for the analysis of by-product gas, as nearly as possible like that already published for producer and blast-furnace gases, with methods for the determination of its content of benzol, total sulphur, and cyanogen. A method for the analysis of natural gas has been incorporated that differs slightly from that given for other fuel gases in that larger quantities for explosion are employed. This feature of the method is of decided advantage, because no error is introduced by a high percentage of resulting carbon dioxide. Elementary calculations of thermal values, specific gravity, and air necessary for combustion are explained and illustrated.

This series of pamphlets, which also includes publications on the sampling and analysis of iron ore, pig iron, steels and coal, coke and by-products, forms a most valuable critical compilation of useful methods based on extended research and wide experience.

* * *

POWDERED COAL AS A FUEL. By *C. F. Herington.* 211 pages, price $3.00 net. New York, D. Van Nostrand Co.

The author collected the material for this book while asistant engineer of the New York Central Railroad Co. The historical notices consist largely of patent abstracts, the descriptions of machinery seem to be taken from manufacturers catalogues, while the chapters relating to the application of powdered coal to various industries are lifted largely from published literature. For instance, Chapter VI, on the application of powdered coal to reverberatory furnaces consists of the two papers by David H. Browne of the International Nickel Co. and Louis V. Bender of the Anaconda Copper Mining Co., presented before the February, 1915, meeting of the American Institute of Mining Engineers. Even the well illustrated chapter on powdered coal for locomotives, where the author presumably has had experience and could speak with authority, is apparently an abstract of J. E. Muhlfeld's paper before the December, 1916, meeting of the American Society of Mechanical Engineers. Elsewhere H. Barnhurst's papers before the Mining Engineers and in this journal, and A. S. Mann's experiments published in the General Electric Review are also quoted very extensively. A bibliography compiled by the Engineering Societies' Library is uncollected as to author, publication, date, subject matter and language.

In the introductory part the author presents estimates of the cost of construction and operation of various comparable systems, showing a great advantage accruing to the Holbeck system. In this the coal is transferred in suspension in air in a closed circuit from the storage bin, through the furnace rooms, and back again, returning the unburned fuel to the starting point. Mr. Herington notes that the most recent developments have been made in utilizing very low grade fuels, such as anthracite culm, and that the amount of ash in the combustible, up to 33 per cent, is not of as great importance in most practices as is whether it produces a "soft" undesirable clinker, or a "hard" brittle clinker giving a light, fluffy ash and little trouble.

The book collects a considerable amount of information as to the proper separation of air from the coal after pulverizing, and as to the proper mixing of air and coal before and during burning. As to the many designs of burners which have been introduced or patented, he quotes the words, "Any mechanism which will give a uniform mixture of coal and air with both under control can be used as a burner for powdered coal."

* * *

METALLURGICAL CALCULATIONS. By *Joseph W. Richards.* One Volume edition, octavo, xxiii + 675 pages. Price $5.00. New York: McGraw-Hill Book Company, Inc. London: Hill Publishing Co., Ltd.

Many users of Dr. Richard's "Calculations" will be pleased to know that a one-volume edition has been issued. Part I, as incorporated herein, has been considerably revised and brought up to date. The separate parts are still obtainable, for the use of students and technologists.

Published originally as a serial in Metallurgical and Chemical Engineering, this treatise on quantitative metallurgy has earned for itself an international reputation; it has in numberless cases pointed the way to a deeper understanding of metallurgical processes and to higher metallurgical efficiency. It has struck the keynote of metallurgical progress in the Twentieth Century.

* * *

STEEL AND ITS HEAT TREATMENT. By *Dennison K. Bullens*, Consulting Metallurgist. Octavo, 483 pages, 285 illustrations; price, $4.00 net. New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd.

This is a second edition of an excellent treatise reviewed in our issue of July 15, 1916. That the book has met with a wide demand is evidenced by the early exhaustion of the first and second impression. In the third printing, the author has availed himself of the opportunity of a thorough-going revision of the text, enabling him to correct many of the errors of omission and commission noted in our earlier review.

Mr. Bullens is to be highly commended for introducing a great deal of matter in his new edition regarding the influence of the human element in heat treatment. He calls attention to the fact that the heat treater is the chef that puts the metallurgical finish on material prepared at great expense by others, and it is his skill and exercise of judgment that determines the final result which either makes or breaks the operation. In many cases the installation of pyrometric equipment merely results that the operator in effect is doing nothing more than manufacturing record charts, instead of properly heating his steel. Good steel is entitled to proper treatment in good furnaces, and both are entitled to the services of good men to produce good results; the best men available are none to good for such important work. Not only is this true, but the strongest language that could be employed to describe the general average heat-treatment equipment, the methods of heating and personnel as they are actually known to exist, would be altogether too mild and ineffective for a proper description of the heating methods and equipment in the majority of forge shops in the country. The apparent advantages of the motor truck were not side-tracked by the fact that it was necessary to teach men how to operate them, and yet there is just as much if not more reason why men, and if necessary a different type of man, should not be taught how properly to heat steel.

* * *

DISEASES OF OCCUPATION AND VOCATIONAL HYGIENE. Edited by *Geo. M. Kober*, M. D., LL. D., and *Wm. C. Hanson*, M. D., aided by 29 Specialists. Octavo (23 x 15 cm.), xxi + 918 pages, 46 illustrations. Price $8.00. Philadelphia: P. Blackiston's Son & Co.

It would be difficult to praise this book too highly. It is written not only to describe Specific and Systemic Diseases of Occupation to medical and legal experts, medical examiners, insurance examiners, practising physicians, teachers, lawyers, students, but also to treat of the Causation and Prevention of such diseases, for the benefit of employers,

employees, public health officials, nurses, social workers, legislators and teachers. The editors themselves wrote most of the chapters on Causation and Prevention, and they are most excellently written. Twenty-two pages on the iron and steel industries, twenty-four on mining and quarrying, seventeen on food industries, thirteen on brass, copper and zinc industries, are examples of the thoroughness of the treatment. The chapters on history, legislation, statistics, etc., are very well written. The book should be found in every industrial plant, and should be well-studied and its teachings closely followed.

Personal

Mr. JULIUS ALSBERG announces the opening of his metallurgical and chemical engineering consulting offices in the Tribune Building, Chicago.

Mr. D. W. BRUNTON of Colorado has been elected a member of the Naval Consulting Board.

Mr. P. B. CHILLAS, Jr., formerly in the Research Laboratory of the National Carbon Co., Inc., is now at the Frankford plant of the Barrett Company, Philadelphia.

ENGINEERING FOUNDATION BOARD has elected the following to membership: Mr. CALVERT TOWNLEY, Westinghouse Electric Mfg. Co.; Mr. SILAS H. WOODWARD, M. Am. Soc.; Dr. JOSEPH W. RICHARDS, Lehigh Metallurgy Dept.; Dr. DAVID S. JACOBUS, Babcock & Wilcox; Mr. H. HOBARD PORTER, Sanderson & Power.

Mr. WOOLSEY MCA. JOHNSON married Miss KATHRYN VERONICA O'HARA, daughter of Mr. and Mrs. W. S. O'HARA of Philadelphia. The couple are now at Washington but later will reside at Cynwyd, Pa.

KENNETH DESPRES KAHN, research metallurgist of Cleveland Brass Manufacturing Co., Cleveland, O., is assistant chemical engineer, division of small scale manufacturing of war chemicals, American University, Experiment Station, Bureau of Mines, Washington, D. C.

Mr. A. LINCOLN KONWISER, formerly superintendent of the Hygiene Chem. Co. at Elizabethport, N. J., and until recently connected with the chrome plant of the Metals and Thermit Corporation, has been appointed factory superintendent and chemical engineer for J. S. & W. R. Eakins, Inc., Brooklyn, N. Y.

Mr. WM. R. LAFFERTY, formerly chemist at the Camden and Bayonne Works of the General Chemical Co., has recently become assistant superintendent at the Bridesburgh, Pa., factory of Charles Lenning & Co.

Mr. WM. A. LEWIS has closed his plant at Monroe and Ferry Sts., Hoboken, N. J., having enlisted in the U. S. Naval Reserves.

FRANK K. MARVIN, formerly Chief Chemist of the Howard Smokeless Powder Co. plant and Aetna Research Laboratory at Emporium, Penn., has been appointed explosives chemist of the Bureau of Mines and stationed at Pittsburgh, Pa.

Mr. E. P. MATHEWSON, who has been with the Anaconda Copper Co., then the British American Nickel Corporation, recently returned to the American Smelting & Refining Co. as consulting metallurgist. He will be at the New York office of the latter company.

Mr. FREDERICK J. MAYWALD has shifted his office and laboratory so that the other entrance of the building at 133 Water Street must be used when entering to consult him.

Mr. JAMES H. READIO, JR., has left the Pawtucket Gas Works to become assistant chemical engineer with the Providence Gas Co.

Prof. G. A. ROUSH of Lehigh University has been appointed supervisor of training, Inspection Division, Ordnance Department. He will have charge of the training of inspectors, recently inaugurated by the War Department.

Mr. FOREST RUTHERFORD, consulting metallurgist, New York City, has been appointed a member of the advisory committee in non-ferrous metals to the U. S. Tariff Commission.

Mr. A. GORDON SPENCER, consulting chemist and metallurgist, Montreal, P. Q., has given up his practice to devote all his time to metallurgical work for Peter Lyall & Sons Construction Co., manufacturers of munitions.

Mr. ROGER TAYLOR has been assigned to the Ordnance Reserve Corps and has therefore severed his connection with the engineering firm of Frederick deP. Hone & Co., New York.

Mr. JOEL H. WATKINS, formerly economic geologist for the Southern Railway, has opened consulting offices at 200 Fifth Avenue, New York, where he will give special attention to the mineral resources of the Appalachian region.

Mr. A. E. WIGGIN has been appointed general superintendent of the Boston & Montana reduction department of the Anaconda Copper Mining Co.

Current Market Reports

Non-Ferrous Metal Market

Friday, June 7.—Prices are tending to be better controlled by the Government. Copper and manganese prices are fixed by law; lead is advancing; tin has fluctuated due to abnormal shipping.

Aluminium.—Government advanced the rate to 33c.

Antimony.—The Government was in the market for 250 tons for July. We quote spot at 12¼ @ 12¾c. futures at 11¼c. c.i.f. in bond.

Chrome.—Producers have established a schedule on the basis of $1.30 per unit ore.

Copper.—War industries board set prices at 23½c. until Aug. 15. Producers' meeting called for Aug. 7.

Lead.—There are widespread inquiries and negotiations for future deliveries, the disposition being to stock up. Prices have advanced to 7⅜c.

Manganese.—Price scale with silica and phosphorus penalties. Unit prices: 40 per cent $1.10, 50 per cent $1.20. See further report.

Molybdenum.—Quoted at $1.25 per lb. of 90 per cent molybdenum sulphide.

Smelter.—Market was stronger; business very light. Quoted at 7¼c. to 7½c.

Tin.—Varying prices. Chinese tin at San Francisco, 86c.; Straits tin, New York, $1.08 to $1.10.

Tungsten.—Scheelite is quoted at $24.00, Wolframite at $19. @ $24.00.

OTHER METALS

Bismuth, lb.	2.50–3.50
Cadmium, lb.	1.40–1.50
Nickel, electrolytic, lb.	.40
Silver, oz. (official)	.99½
Platinum, oz.	105.00
Palladium, oz.	135.00
Cobalt, lb.	2.50–3.50
Magnesium, lb.	2.00
Quicksilver, Cal.	125.00
Quicksilver, Mexican	118.00

The Iron and Steel Market

The distribution of pig iron and steel products, for some months to come if not for the duration of the war, was placed upon a clearly defined basis by the resolution of the War Industries Board, June 6. The actual distribution, however, is not greatly altered from the procedure that has obtained since the producers subscribed, at the close of April, to the pledge of 100 per cent efficiency for war work.

In order to explain briefly what has occurred it is desirable to adopt a nomenclature. One may define "war steel" as material that is ordered directly or indirectly by the government, for its own use or the use of its Allies, "commercial steel" being all other, irrespective of whether or not its employment is helpful towards winning the war. The nomenclature in comon use some time ago, classing industries as "essential" and "nonessential" became taboo in Washington some time ago, the preferable way of looking at the matter being to regard the industries as "more essential" and "less essential," though this is not good English.

For many months the war material has been under direct control of the War Industries Board through the medium of "priority certificates," but there is no precise definition of what classes of material may be the subject of such certificates. By the resolution of June 6 the War Industries Board recognizes three classes of material: (1) Material covered by its priority certificates, which are specific as to the tonnage and description of material involved in each certificate; (2) Material that is covered by a "schedule of purposes entitled to preference treatment" after the material covered by the priorities certificates is taken care of; (3) All other.

Class 2 is essentially the "more essential" material. It is to be distributed by the producers themselves, who are to ascertain from their customers the precise use intended for material furnished, and who are to report precisely each week the tonnages they have shipped, in detail. Hitherto they have reported specifically as to government order numbers, merely giving the total tonnage of all others.

Thus, as to the more essential uses, the War Industries Board prescribes precisely the uses, while the producers distribute the material as to actual tonnages to various customers. The distribution, in other words, is left in the hands of the producers, as they desired. Prior to the New York meeting of April 26 the War Industries Board had contemplated distributing this material also, perhaps by the same machinery of priority certificates as had been in use for war material.

Scope of Recognized Purposes

In form, it is a very drastic operation to cut off supplies of material to Class 3, when it embraces everything not covered by the two preceding classes, and when there is every prospect that there will be little if any material left to be distributed to Class 3. In actual fact, however, the tonnage requirements of Class 3 cannot be large, and material has been denied them almost entirely since the begining of May, and was quite largely denied them for months previously.

In actual fact, however, the deprivation is not great. Building of all descriptions falls in Class 3, unless it is in connection with either of the other classes, but as a matter of fact the building that fails to receive recognition has practically stopped already. There is scarcely any building except in connection with the war, yet in normal times building absorbs a very large part of the steel output. The largest single customer of the steel industry has been railroading, but not only railroads but also other means of transportation, including water transportation specifically mentioned, are named in the "schedule of purposes," while furthermore, since the railroads are under Federal control the specific lots of material required will doubtless be made the subject of priority certificates, and thus fall in the first class rather than the second.

The business of producing and transporting petroleum, and the business of mining coal have been large consumers of steel, but they are included in the schedule of purposes, as relating to fuel. The production and packing of food and the manufacture of clothing for the civilian population are likewise included.

After considering the circumstances referred to in the two preceding paragraphs, it is obvious that there is not much steel to be denied to anybody by reason of his receiving no recognition at Washington at this time. It must be considered further that the great war machine of the United States that is now getting into really powerful operation was not built from the ground up. It was not a case of building shipyards in their entirety, or shell factories, and recruiting them with men who were found outside the regular industries of the United States. Manufacturing facilities that had been always used for the fabrication or working up of iron and steel were largely employed, and thus both plant facilities and men have been diverted in their employment. Thus the normal consumption has largely disappeared in favor of the war consumption. One cannot erect a skyscraper, but the fabricating shops that ordinarily would take the order for the skeleton steel structure are busier than ever, making parts for fabricated ships.

While to individuals finding themselves in the "all other" or third class the dislocation will appear great, in point of tonnage the greatest shortage will be among those finding themselves in the second class, as there will hardly be enough steel to supply fully all their requirements.

Production

There is no material change in the rate of production, which in pig iron is running at between 41,000,000 and 42,000,000 tons a year, with supplies of coke very nearly adequate, and with much new by-product capacity in near prospect, but on the other hand with a period of a couple of months of high humidity facing the furnaces. If a rate of 41,000,000 tons a year is maintained over June, July and August reasonable expectations will have been met, although for a whole twelvemonth the capacity may be taken at not under 43,000,000 tons.

Production of ingots, relative to pig iron or finished rolled steel, is heavier than formerly by reason of the mills endeavoring to swell the production of war steel. This leads them to melt shell discard steel, sheet bar crops, etc., instead of rolling the material into merchantable form.

Prices

The existing set prices expire by limitation June 30 and before the end of the month the War Industries Board will take action on this matter. It is quite foreign to the board's views that there should be any price advances, unless in very special circumstances, and apparently its attitude at the end of March was that there ought to be reductions, but that such action could be deferred by reason of the furnaces and mills having had such poor operating conditions in January and February, so that they could have three months of good times to recoup. However, there was a wage advance of 15 per cent in April and the general advance in freight rates to become effective June 25 will amount to about $1.25 per ton in the manufacture of pig iron and about $2 a net ton in the manufacture of the average rolled steel product. Thus a general reduction in prices may be avoided. There will be no reduction unless the Federal Trade Commission finds the earnings have been running particularly large of late. The matter of large profits for taxation purposes hardly enters now, when the government is itself a very large buyer, but on the other hand the requirements are so large that it is more necessary than formerly to stimulate production to the last ton.

Chemical Market

Heavy Chemical:—During the past two weeks the movement in products under this classification has been rather more pronounced and quite a few more important transactions have transpired. Prices generally have ruled on a somewhat higher level and the tendency appears to be upward in most instances.

Caustic Soda:—The tendency of the market on this commodity has been toward a firm advance during the last two weeks and the trading has been quite active. The standard brands were being quoted at from $1.50 to $1.65 and in several instances $1.70 and $1.75 were spoken of. As to value there was a great difference of opinion in regard to prospects for the balance of the year or even for the next three months.

Soda Ash:—Since our last writing there has been a slight increase in activity accompanied by rising price demand. Against the quotations in our last issue of 2.60 and 2.70 for ash in barrels the offerings at this writing are 2.75 and 2.80 and from store there were a number of offers at from 2.90 to 2.95. Prices on bag material have also slightly advanced and the feeling is of a general underlying strength.

Sulphuric Acid:—The acid situation has developed some points of interest since our last report and the general opinion is that buyers will have difficulty in locating material from now on. The Government's requirements are becoming more pronounced and although there are interests that contend that acid in tanks can still be purchased at from $2.50 to $3.00 works, nevertheless they admit an increasing difficulty in obtaining offers from producers. Drum acid is reported to have sold as high as $55.00.

Oleum:—For twenty degree resale material there have been a few sellers at $55.00 tanks and $65.00 drums. The only producer of 60% material is reported as sold up.

Yellow Prussiate of Soda:—During the latter portion of the last two weeks period there has developed a slight depreciation in price as a result of more frequent offers and a lack of buying interest. Seventy cents was generally quoted although in one instance a possible buy at 68c was reported.

Bichromate of Soda:—Since our last writing which indicated an increasing inquiry interest with prices at 24½c and up to 25c the trend has continued upward and spot material is now held rather generally at from 26c to 26½c, for less than car quantities.

Copper Sulphate:—The inquiries for this product have continued active, quotations ranging around 9c. Many of the offers however undoubtedly are through second hands and have somewhat depressed the market to a slight degree as there developed possible purchases of standard brands of large crystals at 8.50.

COAL TAR PRODUCTS:—The demand for crudes is very quiet and the market in these products reflects considerable ease. Offerings are plentiful and there have been some declines in price registered. The intermediates are firm however and prices are quotably unchanged in most instances.

Benzol:—The market is very easy and offerings are reported of material at attractive prices. The consuming demand is very light and most sales have involved only small quantities.

Phenol:—The situation shows practically no change. The tone is easy with supplies of material continuing to be rather large. There are export inquiries reported that may absorb considerable material but up to the present the difficulty has been in the securing of export licenses for the War Trade Board.

Toluol:—Since the last report the Government through the Raw Materials Division of the War Trade Board has announced fixed prices for the release of toluol whether for non-military use or not. This action was taken in response to complaints from various sources that exorbitant prices were being paid by consumers in comparison with the price the government was paying. The established prices for original releases are 1.50 for large quantities and 1.55 for drums of any quantity. The market as far as real material is concerned shows no alteration and the business being transacted is very light. Releases being made to benzoate of soda producers do not seem to have benefited the resale situation at all.

Naphthalene:—Price declines have been noted and the market is confused with the liberal offerings being made of prime white flakes. Very attractive prices have been quoted for resale material. The ball material is also easier.

Benzoate of Soda:—There have been offerings at attractive prices recently but at the present time these appear to have been absorbed and a firmer appearance to the market is noted. The report has been circulated that the government will take over chlorine which may have added to the firmness which was experienced recently. The demand is fair.

Dimethylaniline:—Production continues to be confined to a few producers. There is fairly active demand and prices have held firm.

Paranitraniline:—Advances have been noted largely because of the acetic acid situation. The requirements of the market are said to be met with although production is confined to a few producers.

Aniline Oil:—With business of moderate proportions passing there is no change to record.

Beta Napthol:—The technical grade continues to be active. There is no change in the sublimed. The demand continues to be fair.

Alpha Napthylamine:—The easy tone evident in this product continues with fair business passing. The amount of supplies continues to meet present requirements.

Metatolumylenediamine:—The demand is unchanged and business of routine nature is passing. Prices show no change.

Paramidophenol:—With price levels unchanged there is a fair demand current.

Phthalic Anhydride:—Prices are firm. The demand is good and the trend seems to be upward.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, JUNE 8, 1918

Acetic anhydride	lb.	1.50 — 1.60
Acetone, drums	lb.	Nominal
Acid, acetic, 28 per cent	lb.	Nominal
Acetic, 56 per cent	lb.	Nominal
Acetic, glacial, 99½ per cent., carboys	lb.	Nominal
Boric, crystals	lb.	.13½ — .14½
Citric, crystals	lb.	.85 — .87
Hydrochloric, C. P	lb.	Nominal
Hydrochloric, 20 deg	lb.	.02½ — .02¾
Hydrochloric, conc., 22 deg	lb.	.02¾ — .03
Hydrofluoric, 30 per cent., in barrels	lb.	.08 — .08½
Lactic, 44 per cent	lb.	15 — .15½
Lactic, 22 per cent	lb.	06 — .06½
Molybdic, 85 per cent	lb.	3 85 — ...
Nitric, 36 deg	lb.	Nominal
Nitric, 42 deg	lb.	.09 — .10
Oxalic, crystals	lb.	.43 — .45
Phosphoric, 47–50 per cent. paste	lb.	.08 — .10
Phosphoric, ref. 50 per cent	lb.	.26 — ....
Picric	lb.	Nominal
Pyrogallic, resublimed	lb.	3.10 — 3.15
Sulphuric, 60 deg	ton	Nominal
Sulphuric, 66 deg	ton	35 00 — 40 00
Sulphuric, oleum (Fuming), tank cars	ton	00 00 — 65 00
Tannic, U. S. P., bulk	lb.	1.30 — 1.35
Tartaric, crystals	lb.	.87 — .88
Tungstic, per lb. of W	lb.	1 70 — 1.75
Alcohol, sugar cane, 188 proof	gal.	4 93 — 4 95
Alcohol, wood, 95 per cent	gal.	.90½ — .91
Alcohol, denatured, 180 proof	gal.	.68 — .69
Alum, ammonia lump	lb.	.04 — .04½
Alum, chrome ammonium	lb.	.17½ — .18
Alum, chrome potassium	lb.	.20 — .21
Alum, chrome sodium	lb.	.12½ — .13
Alum, potash lump	lb.	.08½ — .09
Aluminium sulphate, technical	lb.	.02½ — .03
Aluminium sulphate, iron free	lb.	.03½ — .03¾
Ammonia aqua, 26 deg. carboys	lb.	(Fixed Price)
Ammonia, anhydrous	lb.	Nominal
Ammonium carbonate	lb.	Nominal
Ammonium nitrate	lb.	(Fixed Price) .15
Ammonium, sulphate domestic	lb.	.07¾ — .08
Amyl acetate	gal.	5.40 — 5.50
Arsenic, white	lb.	.09 — .16½
Arsenic, red	lb.	.60 — .70
Barium carbonate, 99 per cent	ton	80.00 — 90.00
Barium carbonate, 97–98 per cent	ton	65.00 — 67.00
Barium chloride	ton	85.00 — 85.00
Barium sulphate (Blanc Fixe, Dry)	lb.	.02½ — .02¾
Barium nitrate	lb.	.09¾ — .10
Barium peroxide, basis 70 per cent	lb.	.30 — .32
Bleaching powder, 35 per cent. chlorine	lb.	.01 — .02
Borax, crystals, sacks	lb.	.07¾ — .08¾
Brimstone, crude	ton	Nominal
Bromine, technical	lb.	.75 — ....
Calcium, acetate, crude	lb.	Nominal
Calcium, carbide	lb.	.16 — .16½
Calcium chloride, 70-75 per cent., fused, lump	ton	27.50 — 30.00
Calcium peroxide	lb.	1.60 — 1.70
Calcium phosphate	lb.	.34 — .35
Calcium sulphate, 98–99 per cent	lb.	.09 — .09½
Carbon bisulphide	lb.	.08¾ — .10
Carbon tetrachloride, drums	lb.	.15½ — .16
Carbonyl chloride (phosgene)	lb.	1.10 — 1.50
Caustic potash, 88-92 per cent	lb.	.81 — .83
Caustic soda, 76 per cent	100 lb.	4 60 — 5.00
Chlorine, liquid	lb.	(Fixed Price) .07½
Cobalt oxide	lb.	1 60 — 1.65
Copperas	lb.	.01½ — .01¾
Copper carbonate	lb.	.30 — .40
Copper cyanide	lb.	.75 — .78
Copper sulphate, 99 per cent., large crystals	lb.	.08¾ — .09
Cream of tartar, crystals	lb.	.65 — .85
Epsom salt, bags, U.S.P	lb.	.03¾ — .03¾
Formaldehyde, 40 per cent	lb.	.17½ — .18¾
Glauber's salt	100 lb.	1.50 — 1.75
Glycerine, bulk, C. P	lb.	.63 — .65
Iodine, resublimed	lb.	4 25 — 4.30
Iron oxide	lb.	.13 — .15
Lead, acetate, white crystals	lb.	.17 — .18
Lead, arsenate (Paste)	lb.	.15 — .18
Lead nitrate	lb.	Nominal
Litharge, American	lb.	.09½ — .10¼
Lithium carbonate	lb.	1 50 — 2.00
Manganese dioxide, U. S. P	lb.	.70 — .75
Magnesium carbonate, technical	lb.	15 — .16
Nickel salt, single	lb.	.14 — .15
Nickel salt, double	lb.	.12 — .14
Phosgene, see Carbonyl chloride		
Phosphorus, red	lb.	1.30 — 1.50
Phosphorus, yellow	lb.	1.25 — 1.40
Potassium bichromate	lb.	.44 — .46
Potassium bromide granular	lb.	1.35 — 1.50
Potassium carbonate, calcined, 85-90 per cent	lb.	.40 — .50
Potassium chlorate, crystals	lb.	.38 — .40
Potassium cyanide, 98-99 per cent	lb.	Nominal
Potassium iodide	lb.	3.75 — 3.80
Potassium muriate 80-85 p. c. basis of 80 p. c.	ton	325.00 — 350.00
Potassium nitrate	lb.	.27 — .31
Potassium permanganate (U. S. P.)	lb.	3.10 — 3.40
Potassium prussiate, red	lb.	2.80 — 2.90
Potassium prussiate, yellow	lb.	1.15 — 1.20
Potassium sulphate, 90-95 p. c. basis 90 p. c.	ton	Nominal
Rochelle salts	lb.	.43 — .44
Salammoniac, gray gran	lb.	.18 — .19
Salammoniac, white gran	lb.	.17½ — .18
Sal soda	100 lb.	1.35 — 1.40
Salt cake	ton	20.00 — 25.00
Silver cyanide, based on market price of silver	oz.	... — ...
Silver nitrate	oz.	.62½ — .63
Soda ash, 58 per cent., light, flat (bags)	100 lb.	2 25 — 2.30

Soda ash, 58 per cent., dense, flat	100 lb.	4 00	—	4 10
Sodium acetate	lb.	Nominal		
Sodium bicarbonate, domestic	lb.	.02½	—	.03
Sodium bicarbonate, English	lb.		—	
Sodium bichromate	lb.	.26	—	.26½
Sodium bisulphite, powd	lb.	.12	—	.13
Sodium chlorate	lb.	.24	—	.25
Sodium cyanide	lb.	.39	—	.40
Sodium fluoride, commercial	lb.	.18	—	.19
Sodium hyposulphite	lb.	.02½	—	.02½
Sodium molybdate, per lb. of Mo	lb.	2.50	—	
Sodium nitrate, 95 per cent	100 lb.	Nominal		
Sodium nitrite	lb.	.28	—	.30
Sodium peroxide	lb.	.35	—	.45
Sodium phosphate	lb.	.04	—	.05
Sodium prussiate, yellow	lb.	.69	—	.70
Sodium silicate, liquid (60 deg.)	lb	Nominal		
Sodium sulphide, 30 per cent., crystals	lb.	.02½	—	.03
Sodium sulphide, 60 per cent., fused	100 lb.	5.50	—	6.00
Sodium sulphite	lb.	Nominal		
Strontium nitrate	lb.	.25	—	.35
Sulphur chloride, drums	lb.	.06	—	.06½
Sulphur dioxide, liquid, in cylinders	lb.	.15	—	.40
Sulphur, flowers, sublimed	100 lb.	4.05	—	4.60
Sulphur, roll	100 lb.	3.70	—	3.85
Sulphur, crude	ton	Nominal		
Tin bichloride, 50 deg	lb.	.27½	—	.28
Tin oxide	lb.	1.00	—	1.25
Zinc carbonate	lb.	.25	—	.30
Zinc chloride	lb.	.12½	—	.13
Zinc cyanide	lb.	Nominal		
Zinc dust, 350 mesh	lb.	.14	—	.16
Zinc oxide, American process XX	lb.	.12½	—	.14
Zinc sulphate	lb.	.04½	—	.05

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.26	—	.30
Benzol, 90 per cent	gal.		—	
Toluol, in tank cars	gal.	(Fixed Price)		1.50
Toluol, for non-military use, in drums	gal.	(Fixed Price)		1.55
Xylol, pure, water white	gal.	.35	—	.50
Solvent naphtha, water white	gal.	.17	—	.22
Solvent naphtha, crude, heavy	gal.	.13	—	.16
Creosote oil, 25 per cent	gal.	.33	—	.35
Dip oil, 20 per cent	gal.	.29	—	.30
Pitch, various grades	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05	—	1.10
Carbolic acid, crude, 50 per cent	lb.	.60	—	.65
Carbolic acid, crude, 25 per cent	lb.	.35	—	.38
Cresol, U. S. P.	lb.	.18	—	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00	—	1.25
Alpha naphthol, distilled	lb.	1.60	—	2.00
Alpha naphthylamine	lb.	.58	—	.60
Aniline oil, drums extra	lb.	.26	—	.28
Aniline salts	lb.	.32	—	.34
Anthracene, 80 per cent	lb.	.50	—	.65
Benzaldehyde (f.f.c.)	lb.	5.50	—	6.00
Benzidine, base	lb.	1.75	—	1.85
Benzidine, sulphate	lb.	1.40	—	1.50
Benzoic acid U. S. P	lb.	3.75	—	3.90
Benzoate of Soda, U. S. P	lb.	3.30	—	3.50
Benzyl chloride	lb.	2.25	—	2.75
Beta naphthol benzoate	lb.	10.00	—	12.00
Beta naphthol, sublimed	lb.	.85	—	.90
Beta naphthylamine, sublimed	lb.	2.65	—	
Dichlor benzol	lb.	.12	—	.18
Diethylaniline	lb.	4.50	—	5.00
Dinitro benzol	lb.	.35	—	.40
Dinitrochlorbenzol	lb.	.40	—	.42
Dinitronaphthaline	lb.	.55	—	.60
Dinitrotoluol	lb.	.55	—	.60
Dinitrophenol	lb.	.46	—	.50
Dimethylaniline	lb.	.70	—	.72
Diphenylamine	lb.	1.00	—	1.10
H-acid	lb	2.30	—	3.00
Metaphenylenediamine	lb.	2.00	—	2.25
Monochlorbenzol	lb.	.17	—	.20
Naphthalene, flake	lb.	.09½	—	.09½
Naphthalene, balls	lb.	.10½	—	.10½
Naphthionic acid, crude	lb.	1.20	—	1.30
Naphthylamin-di-sulphonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.45	—	.50
Nitro toluol	lb.	.50	—	.55
Ortho-amidophenol	lb.		—	
Ortho-dichlor-benzol	lb.	.15	—	.18
Ortho-toluidine	lb.	1.00	—	1.25
Ortho-nitro-toluol	lb.	.75	—	1.00
Para-amidophenol, base	lb.	3.50	—	3.75
Para-amido-phenol, H. Cb	lb.	4.00	—	5.00
Para-dichlor-benzol	lb	.12	—	.15
Paranitraniline	lb.	1.60	—	1.70
Para-nitro-toluol	lb.	1.50	—	1.60
Paraphenylenediamiae (base)	lb.	3.50	—	4.00
Para toluidine	lb.	2.25	—	2.50
Phthalic acid anhydride	lb.	3.50	—	4.00
Phenol, U. S. P	lb.	.48	—	.49
Resorcin, techoical	lb.	5.75	—	6.00
Resorcin, pure	lb.	8.50	—	9.00
Salicylic acid	lb.	.91	—	.95
Salol	lb.	1.90	—	2.00
Sulphanilic acid, crude	lb.	.30	—	.32
Toludin	lb.	2.50	—	
Toluidine-mixture	lb.	.75	—	.85

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4 00	—	
Corning, Ohio	bbl.	2 85	—	
Somerset, Ky	bbl	2 60	—	
Wooster, Ohio	bbl.	2 58	—	
Indiana	bbl.	2.18	—	
Illinois	bbl.	2 32	—	
Oklahoma and Kansas	bbl.	2 25	—	
Caddo, La., light	bbl.	2 25	—	
Corsicana, Tex., light	bbl.	2 35	—	
California	bbl.	1 23	—	
Gulf Coast	bbl	1 35	—	

Fuel Oil

New York	gal	11	—	
Pittsburgh	gal.	07½	—	10
Oklahoma-Kans	bbl.	1 05	—	2 25
Texas	bbl.	1 85	—	2 35
Los Angeles	bbl.	1 60	—	
San Francisco	bbl.	1 60	—	

Gasoline (Wholesale)

New York	gal.	24	—	
Boston	gal.	24	—	
Pittsburgh	gal.	28	—	
Chicago	gal.	22½	—	
Oklahoma	gal.	25	—	
San Francisco	gal.	20	—	

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal	22	—	24
Cylinder, light	gal.	36	—	38
Cylinder, dark	gal.	35	—	36
Paraffine, high viscosity	gal.	40	—	41
Paraffine, .903 sp. gr	gal.	36	—	38
Paraffine, .885 sp. gr	gal.	26	—	28

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	44	—	
Pine oil, steam-distilled, sp. gr. 0.925-0.940	gal.	54	—	
Pine oil, destructively distilled	gal.	49	—	
Pine-tar oil, sp. gr., 1.025-1.035	gal.	35	—	
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	40	—	
Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f. o. b. works	gal.	37	—	
Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f. o. b. works	gal.	28	—	
Pine-tar oil, ref., thin, sp. gr. 1.060-1.080	gal.	32	—	
Turpentine, crude, sp. gr. 0.870-0.900	gal.	40	—	
Hardwood oil, f. o. b. Michigan, sp. gr. 0.960-0.990	gal.	23	—	
Hardwood oil, f. o. b. Michigan, sp. gr. 1.06-1.08	gal.	23	—	
Wood creosote, ref. f. o. b. Florida	gal.	31	—	

Vegetable and Other Oils

China wood oil	lb.	26	—	27
Cottonseed oil, crude	lb.	21	—	22
Linseed oil, raw, cars	gal.	1 57	—	1 59
Peanut oil, crude	gal.	1 35	—	1 36
Rosin oil, first run	gal.	45	—	
Rosin oil, fourth run	gal.	63	—	
Soya bean oil, Manchuria	lb.	.16½	—	.16½
Turpentine, spirits	gal.	52	—	.52½

Miscellaneous Materials

Barytes, floated, white, foreign	ton	Nominal		
Barytes, floated, white, domestic	ton	32 00	—	36 00
Beeswax, white, pure	lb.	62	—	64
Casein	lb.	14½	—	18
Chalk, light, precipitated, English	lb.	Nominal		
China clay, imported, lump	ton	12 50	—	36 00
China clay, domestic, lump	ton	12 50	—	20 00
Feldspar	ton	8 00	—	12 00
Fluorspar, gravel, f. o. b. mines	ton	30 00	—	
Fuller's earth, powdered	100 lb.	1 00	—	1 50
Graphite, flake	lb.	15	—	18
Ozokerite, crude, brown	lb.	Nomioal		
Ozokerite, American, refined, white	lb.	Nominal		
Red lead, dry, carloads	lb	10	—	11½
Rosin, 280 lb.	bbl.	7 50	—	
Soapstone	ton	10 00	—	12 50
Talc, American, white	ton	15 00	—	22 00
White lead, dry	lb.	09	—	10

Refractories, Etc.

(F. O. B. Works)

Chrome brick	net ton	175 00	—	
Chrome cement	net ton	75.00	—	
Clay brick, 1st quality fireclay	per 1000	50 00	—	55 00
Clay brick, seconod quality	per 1000	35 00	—	40 00
Magnesite, raw	ton	30 00	—	35 00
Magnesite, calcined, powdered	ton	50 00	—	65 00
Magnesite, dead burned	net ton	50 00	—	60 00
Magnesia brick, 9x4½x2½	net ton	110 00	—	125 00
Silica brick	per 1000	50 00	—	60 00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent., carloads, f. o. b. Niagara Falls, N. Y	ton		—	
Ferrocerium	lb	15 00	—	20 00
Ferrochromium, per lb. of Cr	lb.		—	
Ferromanganese, domestic, 70 per cent. basis	ton	250 00	—	
Ferromanganese, English	ton	325 00	—	
Ferromolybdenum, per lb. of Mo	lb	5 00	—	
Ferrosilicon, 75 per cent., f. o. b., N. Y	ton		—	
Ferrosilicon, 50 per cent., carloads, del., Pittsburgh	ton	180 00	—	190 00
Ferrosilicon, 50 per cent., contract	ton	160 00	—	170 00
Ferrotungsten, 75-85 per cent., f. o. b., Pittsburgh	lb	2 35	—	2 40
Ferrouranium, f. o. b. works, per lb. of U	lb	2 50	—	
Ferrovanadium, f. o. b. works	lb		—	

Ores and Semi-finished Products

Antimony ore, per unit				
Chrome ore, 45 per cent. minimum, f. o. b. Cal., per unit	ton	1 50	—	1 55
Chrome ore, 45 per cent. and over, New York, per unit	ton			
Manganese ore, 48 per cent. and over, per unit	ton	1 20	—	
Manganese ore, chemical	ton	80 00	—	100 00
Molybdenite, per lb. of MoS_2	lb	1 25	—	
Tungsten, Scheelite, per unit of WO_3	ton	24 00	—	
Tungsten, Wolframite, per unit of WO_3	ton	24 00	—	
Uranium oxide 96%	lb.	3 25	—	3 60
Vanadium pentoxide, 99%	lb	10 50	—	
Pyrites, foreign	unit	17	—	17½
Pyrites, domestic	unit	28	—	30

INDUSTRIAL NEWS

Plant Construction—Catalogs—New Publications

Construction and Operation

Alabama

BIRMINGHAM—The Birmingham Machine & Foundry Co., East Birmingham, will rebuild part of its plant. Estimated cost, $100,000.

MOBILE—The Consumers Dye Wood Products Co., capitalized at $300,000, plans to build a large dye plant here. The foundations of the plant, which will be located at Choctawa Point, have already been put in. G. A. LaVelle, Marietta, O., president.

SHELBY. The Shelby Chemical Co. will build a plant for the manufacture of wood chemicals. Estimated cost, $600,000. M. W. Bush, President of the Shelby Iron Co., is interested

WYLAM (Ensley P. O.)—The Steel Cities Chemical Co., 5 Mine St., Birmingham, will rebuild its plant here recently destroyed by fire.

Arkansas

TEXARKANA—The Texarkana Cotton Oil & Fertilizer Co., 600 East Broad St., will remodel its cotton seed oil mill.

California

LOS ANGELES—The Western Chemical Products Co., manufacturer of potassium permanganate and strontium nitrate, will erect a plant at Vernon.

MARE ISLAND—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., will build an addition to the machine shop at the north end of the Mare Island Navy Yard. Estimated cost, $350,000.

OAKLAND—The Hammer-Bray Foundry, foot of Twenty-sixth Ave., will build the second and third unit of its plant.

SAN FRANCISCO—The Pacific Foundry Co., Eighteenth and Harrison Sts., will build an 80 x 250 ft steel addition to its plant.

TEHACHAPI—The Gold State Mining Co. will install a thirty-ton mill here. Martin J. Errecarte, manager.

Colorado

BONANZA—The Rawley Mining Co. will build a three hundred ton mill here.

Connecticut

HARTFORD—The Colt Manufacturing Co., manufacturer of fire arms, Vandyke Ave., has awarded the contract for the construction of a one-story, 46 x 96 ft., reinforced concrete factory addition to Ellison Construction Co., 60 Prospect St. Estimated cost, $16,000.

HARTFORD—The Terry Steam Turbine Co., Windsor Ave., has awarded the contract for the construction of a one-story, 42 x 468 ft., brick mill construction factory addition to Ellison Construction Co., New Park Ave. Estimated cost, $45,000.

Illinois

CHICAGO—Fleischman Co., 427 Plum St., has awarded the contract for the construction of a four-story, 62 x 85 ft. steel and brick factory on Kingsbury and Weed Sts. for the manufacture of yeast, to H. W. Green Construction Co., 8 South Dearborn Sts. Estimated cost, $90,000.

CHICAGO—The Groen Manufacturing Co., copper-smiths, 2113 North Kenneth Ave., will build a one-story, 50 x 100 ft. brick factory. Estimated cost, $10,000. T. J. Reynertson, 1937 North Crawford Ave., architect.

CHICAGO—The Henry Lindahl Machine Co., Lake and Morgan Sts., has awarded the contract for the construction of a three-story, 50 x 100 ft., mill construction factory to R. L. Brockob, 2122 West Twenty-first St. Estimated cost, $60,000.

CHICAGO—Wilder & Co., 228 West Lake St., has awarded the contract for the construction of a five-story, 50 x 125 ft. reinforced concrete and brick factory for the manufacture of leather, to Mueller Construction Co., 179 West Washington St. Estimated cost, $75,000.

Indiana

ANGOLA—The Sevison Magneto Co. will build a factory here. Estimated cost, $29,000.

HAMMOND—The Standard Steel Car Co. has awarded the contract for the construction of a one-story, 150 x 400 ft. concrete, brick and steel factory for the manufacture of steel tires, to Austin Co., 16112 Euclid Ave., Cleveland, Ohio. Estimated cost, $100,000.

VINCENNES—The Marsh Co., Eleventh and Nicholas Sts., will build a one-story, 65 x 65 ft. addition to its factory to be used for the manufacture of drawn brass and steel tubing. Estimated cost, $32,000.

Kentucky

LOUISVILLE—J. B. Speed & Co., manufacturers of lime and cement, Speed Building, will build a potash plant seven miles from Louisville for the extraction of potash from the clay soil. Estimated cost, $100,000.

Kansas

WICHITA—The Universal incinerator Manufacturing Co. will build a two-story, 50 x 100 ft. reinforced concrete, brick and steel factory. Estimated cost, $25,000.

Maryland

BALTIMORE — The Bartlett-Hayward Co., Scott and McHenry Sts., will enlarge its munitions plant. Estimated cost, $18,000,000. The company purchased something over 21 acres of land on Columbia Ave. several months ago and at the same time took under lease from the City Park Board a much larger area adjoining this tract and Carroll Park.

BALTIMORE—The Rockefeller Foundation, New York City, will build a seven-story, reinforced concrete and brick laboratory on Monument St. to be used by John Hopkins Medical School for research work. Estimated cost, $700,000. Archer & Allen, Central Savings Bank Building, architects.

GLENWOOD—The Baltimore & Ohio R. R., Baltimore has awarded the contract for the construction of locomotive repair shops here, to Westinghouse, Church, Kerr & Co., 37 Wall St., New York City. Estimated cost, $1,700,000.

Massachusetts

BOSTON—Linde Air Products Co., 30 East Forty-second St., New York City, will build a one-story, 125 x 160 ft. reinforced concrete and brick factory for the manufacture of oxygen, on East First and K Sts. Estimated cost, $100,000. T. W. Goodrich, c/o owners, engineer.

CHELSEA—The Chelsea Foundry Co., 333 Third St., will build a one-story, 60 x 100 ft. foundry addition. Estimated cost, $15,000. S. S. Eisenberg, Exchange Building, architect.

HYDE PARK—The Mason Regulator Co., 1190 Adams St., Dorchester, has awarded the contract for the construction of a three-story, 80 x 160 ft. brick manufacturing building here, to John T. Scully Foundation Co., First St., East Cambridge. Estimated cost, $140,000.

ORANGE—The New Home Sewing Machine Co. has awarded the contract for the construction of a one-story, 103 x 353 ft., brick and steel plant for the manufacture of shells, to Casper Ranger Construction Co., Bond St., Holyoke. Estimated cost, $70,000.

ROXBURY—The Trustees of Harvard College, Harvard Medical School, Cambridge, will build a laboratory at 695 Huntington Ave. Estimated cost, $60,000. Coolidge & Shattuck, 122 Ames Building, Boston, architects.

Michigan

DETROIT—The Murchey Machine & Tool Co., Richmond Ave. and East Grand Boulevard, will build an addition to its plant.

MUSKEGON—The Campbell, Wyant & Cannon Foundry Co., Sanford St. and McKinney Ave., Muskegon Heights, has purchased ten adjoining lots and will build an addition to its plant.

PONTIAC—The Precision Castings Co. will rebuild its plant here which was partly destroyed by fire entailing a loss of $50,000.

Missouri

JOPLIN—The North American Mining Co., 715 Frisco Building, will build a concentrating plant at its mine, requiring sludge tables, compressors and crushers. Estimated cost, $60,000. W. R. Shanklin, 715 Frisco Building, mine engineer.

JOPLIN—Playter Bros. Mining & Reality Co., 315 Wall St., will build concentrating plant here. Estimated cost, $75,000. A. M Brannon, trustee.

JOPLIN—The Reindeer Lead & Zinc Co. will build a one hundred and fifty-ton concentration mill at its mine here. Estimated cost, $40,000.

KANSAS CITY—The Butler Manufacturing Co., manufacturer of steel products, 1324 Grand Ave., will build a one-story, 125 x 270 ft. plant on Eastern Ave., Sheffield.

ST. LOUIS—The Moon Motor Car Co., 4401 North Main St., has received a $2,000,000 order for large shells for the army and will build extensive additions to its plant here. The McDonald Engineering Co. ,an engineering subsidiary, will assist in the manufacturing.

ST. LOUIS—The St. Louis Lead & Oil Works, Manchester and Sublette Aves., has awarded the contract for the construction of a reinforced concrete and steel paint factory, to Chapline Construction Co., Post Dispatch Building. Estimated cost, $15,000.

Montana

BOZEMAN—The Montana State College of Agriculture and Mechanic Arts, has awarded the contract for the construction of a chemical laboratory, to Kroffganz & Frank, Butte.

Nebraska

OMAHA—The Overland Rubber & Tire Co. has purchased a site of land running from Thirteenth St. to Thirty-first Ave. and from Taylor St. north, to the Missouri Pacific Belt line on the south, and will build a plant here for the manufacture of tires and tubes of all kinds both for automobiles and trucks, and a general line of mechanical and surgical rubber goods. Estimated cost, $2,000,000.

PLATTSMOUTH—The Auto Power & Malleable Manufacturing Co., 729 First National Bank Building, Omaha, will build a one-story, 80 x 240 ft. foundry of fabricated steel and glass on a site surrounded by Main, Pearl, Second and Third Sts. Estimated cost, $150,000.

New Jersey

BLOOMSBURY—The Warren Manufacturing Co., manufacturer of paper, will build large additions to its plant. E. H. Wenzelberger, Reading Building, Easton, Pa., is architect

BOUND BROOK—The Calco Chemical Co., Bound Brook Road, will build additions to its plant. Estimated cost, $250,000.

ELIZABETH—Duesenberg Motor Corporation, Newark Ave., will build a brick testing plant. About $90,000.

HARRISON—The National Oil Products Co., Essex St., has acquired the plant here formerly owned and operated by the Elm Park Linoleum Works, Elm Park, Staten Island, and will equip same for its own use. The works comprise a twelve acre site with fourteen manufacturing buildings covering an area of about 250,000 sq.ft. floor space.

NEWARK—Martin Dennis Co., 859 Summer Ave., has awarded the contract for the construction of a one-story, brick factory for the manufacture of chemicals, to Salmon Bros., 526 Elm St., Arlington. Estimated cost, $30,424.

NEWARK—The Mass & Waldstein Co., 437 Riverside Ave., has awarded the contract for the construction of two one-story, 56 x 216 and 56 x 128 ft. brick buildings for the manufacture of chemicals, to H. M. Doremus Co., 36 Orange St. Estimated cost, $40,000.

NEWARK — The Mennen-Gerhardt Chemical Co., 40 Spring St., will alter its factory on Central Ave. Estimated cost, $42,500.

NEWARK—The Pierce-Butler & Pierce Manufacturing Co., 437 East One Hundred Sixty-second St., New York City, will build a one-story, 50 x 200 ft., concrete factory for the manufacture of steam and water boilers and plumbing fixtures on Colt St.

NEWARK—The United Oil & Chemical Co., Ave. R, will build a three-story addition to its plant.

PATERSON—The East Jersey Pipe Works, East Thirty-Sixth St., has purchased a site between 371 and 585 East Thirty-Second St., upon which a large addition will be erected.

New York

BIDGEFIELD PARK—The British American Chemical Co., 52 Vanderbilt Ave., New York City, has awarded the contract for the construction of factory buildings here, to Snare & Triest Co., 8 West 40th St., New York City.

BUFFALO—The National Aniline & Chemical Co., 351 Abbott Road, will build a three-story, brick and steel machine shop. Estimated cost, $85,000.

BUFFALO—The O'Neill Iron Works, 29 Perry St., will build a one-story brick and steel shop addition to its plant. Estimated cost, $45,000.

CORTLAND—The Cortland Specialty Co., 178 Railroad St., manufacturer of chemicals, will build an addition to its plant.

GLOVERSVILLE—G. Levor Co. has awarded the contract for the construction of a two-story, 75 x 115 ft. concrete and brick factory on Woodside Ave. for the manufacture of leather to A. E. Brace, 37 Hamilton St. Estimated cost, $35,000

LONG ISLAND CITY—The Meurer Steel Barrel Co., 575 Flushing Ave., will rebuild its one and two-story, 200 x 255 ft. brick factory on Third and Oliver Sts. Estimated cost, $75,000. L. Allmendinger, 20 Palmetto St., Brooklyn, architect

ROCHESTER—The High Speed Hammer Co., 307 St. Paul St., has awarded the contract for the construction of a 60 x 115 ft. machine shop on Norton St., to Curran & Swartout Co., Granite Building. Estimated cost, $25,000.

Ohio

CANTON—The Timken Roller Bearing Co., Deuber Ave., has awarded the contract for the construction of new factory buildings, to J. E. Moss Iron Works, Wheeling, West Virginia

CINCINNATI—The Cincinnati Gear Co., 1825 Reading Road, has awarded the contract for the construction of a one-story, 40 x 100 ft. concrete and brick addition to its factory to H. C. Hazen Co., 2070 Reading Road. Estimated cost, $30,000

CINCINNATI—The Proctor & Gamble Co., Gwynne Building, will build a three-and one-half story, brick and concrete factory between East Ave. and Millereek, Ivorydale. Estimated cost, $40,000.

CLEVELAND—The Cleveland Armature Co., 4732 St. Clair Ave., has awarded the contract for the construction of a two-story, 40 x 150 ft., reinforced concrete and brick factory, to the McMillin Co., 1794 East Fifty-Fifth St. Estimated cost, $20,000

CLEVELAND—The Cleveland Pneumatic Tool Co., 3734 East Seventy-Eighth St., has awarded the contract for the construction of a one-story, 51 x 182 ft. concrete and brick factory, to Allen Osborn Engineering Co., 700 Rose Building. Estimated cost, $35,000.

CLEVELAND—P. A. Geier, manufacturer of machinery, 5100 St. Clair Ave., will build a one-story, brick addition to its plant. Estimated cost, $12,000 Watson Engineering Co., Hippodrome Building, engineer.

CLEVELAND—The Independent Glue & Gelatine Co., 2106 Woodland St., will build a two-story, 84 x 186 ft. brick factory on Broadway near Twenty-Eighth St

CLEVELAND—The Reflex Ignition Co., 1788 Payne Ave., has purchased a site on West One Hundred and Sixth St. and will build a factory.

DAYTON—The Platt Iron Works, Keowee and Valley Sts., will build a one story metal factory. Estimated cost, $15,000.

MANSFIELD—The Rederick Lean Manufacturing Co., 366 Park Ave. East, will build a 100 x 420 ft machine shop and tool room addition to its factory

YOUNGSTOWN—The Raymond Concrete Pile Co., Andrews Ave., will build a 27 x 60 x 300 ft. brick factory for the manufacture of shells Estimated cost, $30,000.

Oklahoma

BARTLESVILLE—The Bureau of Mines has awarded the contract for the construction of a two story, 37 x 57 ft administration building and a 42 x 102 ft laboratory, to D. M. Wall, 2617 Agnes St Estimated cost, $30,000.

OKLAHOMA CITY—The Greater States Oil Corporation has purchased a forty acre site near Eastland upon which it will build an oil refinery Estimated cost $200,000

TULSA—The Lamphlack Manufacturing Co. will build a plant for the manufacture of lamphlack from natural gas

WALTERS—The United States Refinery Co. has purchased an eighty acre site here on which it will build an oil refinery Estimated cost, $60,000

Oregon

ASTORIA—The Astoria Paper Mills will build an addition to its plant Estimated cost, $250,000

Pennsylvania

BRISTOL—The Atlantic Refinery Co., 3144 Passyunk Ave., Philadelphia, has awarded the contract for the construction of a one-story addition to its plant here to Metzger & Fisher, Otis Building, Philadelphia.

PHILADELPHIA—The Barrett Co., Margaret and Bermuda Sts. has awarded the contract for the construction of a five story, 100 x 150 ft. reinforced concrete and brick factory for the manufacture of coal tar products, to A. R. Raff Construction Co., 1616 Thompson St. Estimated cost, $40,000

PHILADELPHIA—Berko Bros., Randolph and Wood Sts., manufacturer of structural steel, has awarded the contract for the construction of a one-story, 75 x 85 ft. brick ware factory, to M. Yellin, 7L North Franklin St. Estimated cost, $5,000

PHILADELPHIA—The Powers-Weightman-Rosengarten Co., 916 Parrish St., manufacturer of chemicals will build a one story, 55 x 70 ft addition to its plant at Ridge Ave. and Calumet St.

PITTSBURG—The Atlantic Refining Co., Fifty-Seventh and Butler Sts., will build a pressure still at its plant Estimated cost, $50,000.

READING—The International Money Machine Co., Kutztown Road, has awarded the contract for the consstion of a two story, 40 x 45 ft and a one story 60 x 142 ft concrete and steel factory buildings, to Austin & Co., Bulletin Building, Philadelphia. Estimated cost, $50,000.

Rhode Island

NEWPORT—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids June 3rd for building a chemical laboratory at the U. S. Naval Torpedo Station, from T. A. Cassidy, 54 Ballston St., Fitchburg, Mass., $47,571, C. B. Maguire, Providence, $31,955, Darling Slade Construction Co., Newport, $36,000

Texas

COLEMAN—The Lone Star Oil & Refining Co., Manes Building, will erect an oil refinery to have a daily capacity of 500 barrels. Estimated cost, $50,000

HOUSTON—The Ka-Tex-O Oil & Refining Co. will build a large oil refinery here

Virginia

PORTSMOUTH—The Lime-Kola Co. will build a flavoring extract plant at 611 Edwards St.

Washington, D. C.

WASHINGTON—The Bureau of Yards & Docks, Navy Department, has awarded the contract for the construction of a mine laboratory, to Sumner Sollitt Co., Pullman Building, Chicago, Ill. Estimated cost, $75,000

Washington

SEATTLE—The American Foundry Co., 408 Occidental Ave., recently organized, will build an iron foundry with a daily capacity of fifteen to twenty tons.

SEATTLE—The Ark-O-Lith Products Co. will build a two story, 24 x 48 ft factory at 121 Wilton St. for the manufacture of building blocks, artificial marble and fireproof doors

SEATTLE—Gulowsen & Grei Co. Alaska Building, will build a one story 174 x 300 ft. hull construction. Grei engine manufacturing plant on Salmon Bay. Estimated cost $400,000. S. E. Sonnichsen, Downs Block architect

SEATTLE—The Heffernan Engine Works, 108 Railroad St. will build a two story, 50 x 174 ft. machine shop. Estimated cost, $25,000

SEATTLE—The Pacific Engineering & Construction Co. will build a one story, 70 x 120 ft addition to its machine shop and foundry

West Virginia

HUNTINGTON—The Chesapeake & Ohio Railroad Co., Richmond, Va., will build a one story machine shop here Estimated cost $500,000. F. J. Cabell, Richmond, chief engineer

WESTON—State Board of [illegible] having plans prepared for sewerage treatment plant for Weston State Hospital. The plant will consist of pumping [illegible] mentation tank, sprinkling filter, disinfecting plant and incinerating plant. Estimated cost $45,000. Charles [illegible] Drexel Building, Philadelphia, [illegible] neer

Wisconsin

MILWAUKEE—The National Brass & Metal Co. has let contract for [illegible] Foundry Co. for the erection of a [illegible] to its factory here. Estimated cost $[illegible]. H. J. Luer & Co., [illegible] engineers

MILWAUKEE—The [illegible] Wire & Iron Works, Reed St. and [illegible] Ave., has let contract to the Fuller-Lehr Co. for the erection of a one story, 75 x [illegible] ft. factory and office building. Estimated cost $[illegible]

WAUWATOSA—The Milwaukee Lighting Fixture Co., Thirteenth and Lloyd Sts., will build a one story, 75 ft. addition to its plant.

WYOMING PARK—The Heath Motor Car Co. has awarded the contract for the construction of a one story, 75 x [illegible] ft. factory and office building to J. W. Cook, Grand Haven, Mich.

Wyoming

WORLAND—The Pioneering Oil Products Co., Exchange Building, San Francisco, Cal. has purchased the Hyde Consolidated Refinery and will install an additional plant. Estimated cost $500,000

Ontario

BRANTFORD—The Motor Trucks Co., Ltd., Eagle St. has awarded the contract for the construction of a brick and steel shop and factory to P. H. Secord & Sons. Estimated cost $175,000

HAMILTON—The Dominion Steel Foundry Co., Depew St., will build a new plant. Estimated cost $[illegible],500,000

OWEN SOUND—The Great Lakes Steel Corporation, Ltd., 22 King St., East, Toronto, has purchased a factory here which it will remodel for the manufacture of steel products.

TILBURY—The Canadian Forgings & Socket Co. will build a foundry plant here. Estimated cost, $2,000

WINDSOR—The Menard Motor Truck Co., 100 London St., West will build a three story brick factory. Estimated cost $60,000. M. L. Menard, 10 Carson St. is manager

Canada

DESCHENES—The British American Nickel Corporation, Royal Bank Building, Toronto, has awarded the contract for the construction of a copper refining plant here to Bate, McMahon & Co., Ottawa. Estimated cost $1,000,000

LONGUE POINTE—The Montreal Locomotive Works, 145 St. James St., Montreal, will build an addition to its plant here

MONTREAL—The Canadian Aloe Chalmers Ltd., 162 St. Antoine St., will build a concrete, brick and steel addition to its Rockfield plant here. Estimated cost $25,000

Industrial Notes

THE DENVER FIRE CLAY COMPANY, Denver, Colo., founded in 1876, has recently been reorganized as a result of the purchase of the entire interest held by Wm. W. Case, Jr., by Mr. Leonard Buckwalter, wife of the founder of the business, and her three sons. Arthur H. senior member of the firm Buckwalter, Chanute & Company, Denver; Harold O. of New York and Capt. Robert B. an attorney of Denver, now in the American military service in France. This company specializes in clay products for smelting and other metallurgical work, produced from its own fire clay deposits near Golden, Colo. The company is also a large importer and exporter of all kinds of chemicals for laboratory and industrial purposes. The officers of the new company are as follows: President, Harold O. Bosworth who was formerly active in the company for 16 years, last as sales manager of the White Tar Company of New York. Vice-president, Claude Evans, recently manager of the assay department of the Mine & Smelter Supply Company, Denver. Secretary-Treasurer, Herman Landenberger who has been connected with the company for 20 years. George W. Lindsay will be factory superintendent

THE SEAMEN-KENT METALS COMPANY, Ltd., Montreal, one of the pioneers in the production of ferromanganese in America, has established a sales office in the Leader-Scott Building, Cleveland, O., with P. Pierce in charge.

THE NATIONAL ANILINE AND CHEMICAL Company transferred to exhibit quarters recently given at the Textile Show to the Work in U. S. A. exposition at the Grand Army Armory of Boston, which was particularly applicable to the purpose of the Latin-American Commercial League of the manner in which it demonstrates the growth and importance of the American dye industry

The [illegible] Company of America, Inc., has built and equipped a new factory, 721-733 East 133rd Street, New York City. The new building was occupied on April 25 and the company is now in position to make any article of fused silica demanded by the trade.

The Booth-Hall Company announce contracts recently received for the following units: A 1-ton furnace for the Queen City Foundry Company, Denver, Col., which is at present operating a converter steel foundry. A 2-ton furnace for the Monroe Steel Casting Company, Monroe, Mich., which is at present operating a single-phase electric furnace which will be replaced by the new unit. A 2-ton furnace for the New England Steel Casting Company, a new steel foundry which will be located at Springfield, Mass. A 2-ton furnace for the Four-Wheel Drive Auto Company, Clintonville, Wis., which is installing a new steel foundry to produce castings for trucks for the United States government. A 2-ton Booth-Hall furnace has recently been put into operation in the new steel foundry of the Avery Company, Peoria, Ill., for producing gears, pinions, and other agricultural machinery and tractor castings. A 1-ton unit is ready to be put into operation at the plant of the Duriron Castings Company, Dayton, Ohio. With the 5-ton unit which has been in operation at the Midland Electric Steel Company, Terre Haute, Ind., this makes three sizes of furnaces that the Booth-Hall Company has designed and put in operation.

The Everly N. Davis Chemical Corporation is a new company formed for the specific purpose of equipping and operating the new picric acid plant which is to be built by the War Department at Little Rock, Ark. Everly N. Davis, the president of the company, was formerly president of the Butterworth-Judson Corporation. The new company has just opened offices at 25 West 44th Street, where they are interested in hearing from reliable manufacturers of chemical equipment which they shall need in their plant.

The Driver-Harris Company of Harrison, N. J., announces the election of the following officers: Frank L. Driver, president; Arlington Bensel, 1st vice president; Leon O. Hart, 2nd vice president; Frank L. Driver, Jr., 3rd vice president; Percival E. Reeves, treasurer; Stanley M. Tracy, asst. treasurer; M. C. Harris, secretary. Mr. Wilbur B. Driver, formerly vice president, has retired from active participation in the business.

The Brown Hoisting Machinery Co. announces the appointment of Mr. H. D. Wright, manager of the San Francisco office, as Pacific Coast representative, to succeed the Colby Engineering Company in the Northwest territory.

The Brown Instrument Company, Philadelphia, has opened a new office at 2086 Railway Exchange Building, in charge of Mr. Paul H. Berggreen. The new office is established to meet the demands of business in the Southwestern part of the country.

The Marden, Orth & Hastings Corp., Cleveland, O., branch, moved into new offices in the Illuminating Building. The Cleveland office is in charge of Mr. Henry W. Galley, and takes care of all the trades using colors, chemicals and industrial and edible oils in the State of Ohio and in the Pittsburgh, Pa., and Louisville, Ky., districts.

Fuller-Lehigh Company is the style of the merger of the property and plants of the Lehigh Foundry Company and the Lehigh Car, Wheel & Axle Works of Fullerton, Pa. The properties of the two companies are adjoining and have been for a number of years under the same management. The change is one of name only. The executive personnel remains the same, and the same high standards of quality of products and efficiency of service established in the past will be maintained. The office and works are at Fullerton, Pa.

Mitsui and Co., Ltd., announce the removal of their office to 65 Broadway, New York City.

The Joseph Dixon Crucible Company announces the election of the following directors and officers at the last annual meeting: Directors: George T. Smith, William G. Bumstead, J. Schermerhorn, George E. Long, Edward L. Young, Harry Dailey, Robt. E. Jennings. Officers: George T. Smith, president; George E. Long, vice president; J. H. Schermerhorn, vice president; Harry Dailey, secretary; William Koester, treasurer; Albert Norris, asst. secretary and asst. treasurer.

The American Graphite Company, a subsidiary of the Joseph Dixon Crucible Co., has the same directorate as the Joseph Dixon Crucible Co. and the following officers: George T. Smith, president; George E. Long, vice president; J. H. Schermerhorn, treasurer; Harry Dailey, secretary.

Colorado Iron Works Company announces the removal of its Eastern office to 30 Church Street, New York City.

Sir Isaac Pitman & Sons, Ltd., announces the recent purchase of all the existing copyrights of the numerous scientific and technical books previously issued by Messrs. Whittaker & Company of London, and in future the American agency for these works will be controlled by Isaac Pitman & Sons, 2 West 45th Street, New York. This series includes many important works relating to aeroplanes, submarines, wireless telegraphy, etc.

The Wilputte Coke Oven Corporation has been awarded a contract for the construction of forty (40) Wilputte ovens, with extensions to the existing byproduct plant and benzol plant, by the Citizens Gas Company of Indianapolis. Work has been started and the plant is expected to be in operation by December, 1918.

The Wheeler Condenser & Engineering Co., Carteret, New Jersey; Bulletin 108-B on centrifugal pumps, illustrating the turbine-driven geared centrifugal pumps; bi-rotor, tri-rotor; electric driven; small belt-driven; small high-speed; side, end and bottom suction; vertical shaft; pumps for either series or parallel operation; and special slow-speed engine driven pumps. Test curves made by both manufacturer and customer are included.

Clarage Fan Company, Kalamazoo, Michigan, Catalog No. 7 on section drying cabinets giving details of dryer and prices.

The Cutler-Hammer Mfg. Co., Milwaukee, Wis.; a folder illustrating and describing the battery charging equipment for industrial electric trucks. Also a folder, No. 233, on C-H Industrial Stores.

The Walter A. Zelnicker Supply Company, St. Louis, Mo.; Bulletin No. 243, May 14, 1918, on power plant equipment and machinery for immediate shipment.

The Armstrong Cork & Insulation Company, Pittsburgh, Pa.; a booklet entitled "Satisfaction or ——" which deals with the subject of industrial drinking water systems. Copies will be supplied upon request.

The M H-Aterite Company, Inc., 55 John Street, New York; Bulletin No. 4, Jan. 1, 1918, on special information for superintendents of oil refineries in relation to valves, fittings, etc.

The Locomotive Pulverized Fuel Company, 30 Church Street, New York; Bulletin 4, March, 1918, on the use of powdered coal or lignite with "Lopulco" combination feeder and mixer.

The Allis-Chalmers Manufacturing Company; Bulletin 1454, January, 1918, on their dust collector.

The Buffalo Forge Co., Buffalo, N. Y.; Sections No. 100 and 108 describing portable and stationary forges.

J. H. Mathews & Sons, Wellsburg, West Va.; a booklet entitled "Builders of Glass Works."

Gem Stopper Company, Philadelphia, Pa., Bulletin No. 8, January, 1918, on universal acid carboy stoppers, asbestos gaskets and metal fasteners.

New Publications

Tycos Gravity and Temperature Tables for Mineral Oils from Determinations of the Bureau of Standards and Other Tables for General Testing and Refinery Practice. Compiled and edited by E. N. Hurlburt. Published by the Taylor Instrument Companies, Rochester, N. Y. Price, $1.00.

Report of a Conference held under the auspices of the Committee on Work in War Industries of the National War Work Council, Young Men's Christian Association. Among the speakers were Judge E. H. Gary, A. C. Bedford, John J. Eagan, and others.

The Rockefeller Foundation, A review of its war work, public health activities, and medical education projects in 1917. By George E. Vincent.

University of Texas Bulletin, No. 1752, Sept. 15, 1917. Boiler Waters; Their Chemical Composition, Use, and Treatment. By W. T. Read, Chemist, with a preface by E. P. Schoch, head of the Bureau of Economic Geology and Technology Division of Chemistry.

New Geological Survey Reports: Lime in 1916. By G. P. Loughlin; Mineral Waters in 1916. By Arthur J. Ellis, with a comparison of American and European mineral waters. By Alfred A. Chambers; Gold, Silver, Copper, Lead and Zinc in Idaho and Washington in 1916. By C. N. Gary; and Copper in 1916 (general report), By B. S. Butler.

New Bureau of Mines Publications: The Use of Permissible Explosives in the Coal Mines of Illinois. By James R. Fleming and John W. Koster, Bulletin 137; Concentration Experiments with the Siliceous Red Hematite of the Birmingham District, Alabama. By Joseph T. Singewald, Jr., Bulletin 110; Oil-Storage Tanks and Reservoirs, with a brief discussion of losses of oil in storage and methods of prevention. By C. P. Bowie, Bulletin 155; and Initial Priming Substances for High Explosives. By Guy B. Taylor and W. C. Cope, Technical Paper No. 162.

The Storage of Bituminous Coal. By H. H. Stock, University of Illinois. Bulletin Vol. 15, No. 27. A 200-page pamphlet issued in view of the recent coal shortage. It is the purpose of the circular to present a review of modern practice governing the storage of coal. The discussion is confined to bituminous coal which has given so much trouble owing to its tendency toward spontaneous combustion while stored. Another pamphlet bearing on the same subject is Technical Paper No. 172 of the U. S. Bureau of Mines, "Effects of Moisture on the Spontaneous Heating of Stored Coal" by S. H. Katz and H. C. Porter.

The Thermal Testing Plant. By R. B. Fehr. Bulletin No. 24 of the Engineering Experiment Station, of the Pennsylvania State College. A report on the work of the testing plant for the years 1916 and 1917, describing apparatus and method of testing, calibration of instruments, etc.

Manufacturers' Catalogs

The Galvanizing Corporation of America, Brooklyn, N. Y.; a booklet on Electro-Galvanizing the "Standard" Way, showing the advantages of lime as a protective agent.

Ludlum Steel Company, Watervliet, N. Y.; a catalog on the manufacture of steel and the use of various alloy elements. The language employed throughout the catalog is that of the shop man and not the metallurgist. This catalog and treatise on the allotropy of steel and the alloying of steel is for distribution, free of charge.

The Hydraulic Press Mfg. Co., Mount Gilead, Ohio; a new catalog on hydraulic valves and fittings, describing this company's complete line, including hydraulic presses, pumps, accumulators and intensifiers for every high-pressure purpose. Copies may be had by addressing the above company.

The Harshaw Fuller & Goodwin Company, Cleveland, Ohio, a book on "Enamels" by Robert D. Landrum. This book is a collection of various articles published by the author in the different technical journals.

Link-Belt Company, Chicago, Ill.; Book No. 312 on the silent chain, the efficient drive for machine tools.

The Titanium Bronze Company, Inc., Niagara Falls, N. Y.; a booklet on high-conductivity copper castings.

The United Filters Corporation, Brooklyn, N. Y., has issued three bulletins, Nos. 100 to 102 inclusive, covering Kelly and Sweetland pressure leaf-type filters, also the American continuous vacuum filter.

W. S. Rockwell Company, 50 Church Street, New York: Bulletin No. 34 on forging and heating furnaces describing the Economzer shield type, issued May, 1918; Bulletin No. 35 on annealing furnaces, rolling mill type.

Monarch Engineering & Manufacturing Company, Baltimore, Maryland: A bulletin describing the new Monarch vertical non-crucible tilting metal melting furnace.

The Pfaudler Co., Rochester, N. Y.: Bulletin C5 on glass enameled steel equipment for the chemical industries.

Colorado Iron Works Company, Denver, Colorado: Catalog No. 28-C on the continuous filtration with the Portland filter, distributed in the East by the Colorado Iron Works Company, 30 Church St., New York City.

Hoskins Manufacturing Co., Detroit, Mich.: Catalog No. 3, April, 1918, on Hoskins pyrometers and chromel couples.

James G. Biddle, 1211-13 Arch Street, Philadelphia: A bulletin on Biddle's engineering specialties for testing.

The Harris Calorific Co., Cleveland, Ohio: A bulletin on high temperature gas apparatus and also welding and cutting of metals.

Wheeler Condenser & Engineering Company, Carteret, N. J.: A catalog on the Lillie evaporator for waste waters, including tank waters, runaway waters, distillery slops, steffins waters, etc.

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